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FM 44-2

T OF THE ARMY FIELD MANUAL

ANTIAIRCRAFT ARTILLERY AUTOMATIC WEAPONS

DEPARTMENT OF THE ARMY • AUGUST 1950

~~RESTRICTED~~

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FM 44–2

This manual supersedes FM 44–2, 21 December 1944; FM 44–11, 22 August 1945; and FM 44–51, 19 September 1944

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CONTENTS

This manual supersedes FM 44-2, 21 December 1944; FM 44-11, 22 August 1945; and FM 44-51, 19 September 1944.

PART ONE
ORGANIZATION AND TACTICS

CHAPTER 1
GENERAL

Section I. INTRODUCTION

1. GENERAL. a. This manual presents the basic principles and methods of application of antiaircraft artillery automatic weapons gunnery, fire control, and employment on the battalion and battery levels. All the necessary material plus new developments in organization, tactics, gunnery, and fire control are included.

b. The manual is organized in two parts—Part I, Organization and Tactics; Part II, Fire Control and Gunnery.

2. ANTIAIRCRAFT MISSION. The antiaircraft mission of antiaircraft artillery automatic weapons is to attack all forms of enemy aircraft, to destroy them, to nullify their effectiveness, or to cause them to abandon their mission. The term enemy

aircraft includes subsonic air-to-surface glide and jet-propelled bombs, subsonic surface-to-surface guided missiles, pilotless aircraft, and any other similar type weapon; since these missiles cannot be caused to abandon their mission, they must be destroyed by the automatic weapons.

3. SURFACE MISSION. The surface mission of automatic weapons is to provide close fire support for infantry (armored) units by reinforcing the fires of infantry heavy weapons and to attack and destroy targets of opportunity on land or on water.

4. DETERMINATION OF MISSION. a. Commanders whose forces include antiaircraft artillery assign it that mission dictated by consideration of the greatest threat to the over-all mission of the force.

b. Antiaircraft artillery will be so emplaced as best to accomplish the assigned mission. Whenever possible, without prejudice to the assigned mission, it also will be sited so as to facilitate attacking targets other than those specifically included in that mission.

Section II. ORGANIZATION

5. BATTERY ORGANIZATION. a. The automatic weapons battery consists of two platoons of four firing sections each. Each firing section is made up of a machine-gun squad and an automatic weapons squad. Each of these squads is a fire unit and is referred to as such. The type of equipment authorized for the automatic weapons

battery varies in accordance with the tables of organization and equipment.

b. The mobile firing section armament consists of the 40-mm antiaircraft gun on carriage M2A1, director M5A3, power plant, and multiple caliber .50 machine-gun trailer mount M55. The section is divided into a machine-gun squad and an automatic weapons squad; each squad is a fire unit.

c. The self-propelled firing section consists of a multiple machine-gun motor carriage M16 and a twin 40-mm gun motor carriage M19. The section is divided into a machine-gun squad and an automatic weapons squad; each squad is a fire unit.

d. The airborne firing section consists of the 40-mm antiaircraft gun on carriage M2A1 and the multiple caliber .50 machine-gun trailer mount M55. The section is divided into an automatic weapons squad and a machine-gun squad; each squad is a fire unit.

6. BATTALION ORGANIZATION. The battalion is the basic self-contained administrative and tactical unit of antiaircraft artillery. There are three types of automatic weapons battalions—mobile, self-propelled, and airborne. Their organization is as follows:

a. Mobile automatic weapons battalion and medical detachment. The battalion consists of a headquarters and headquarters battery and four mobile firing batteries (fig. 1).

b. Self-propelled automatic weapons battalion. The battalion consists of a headquarters and head-

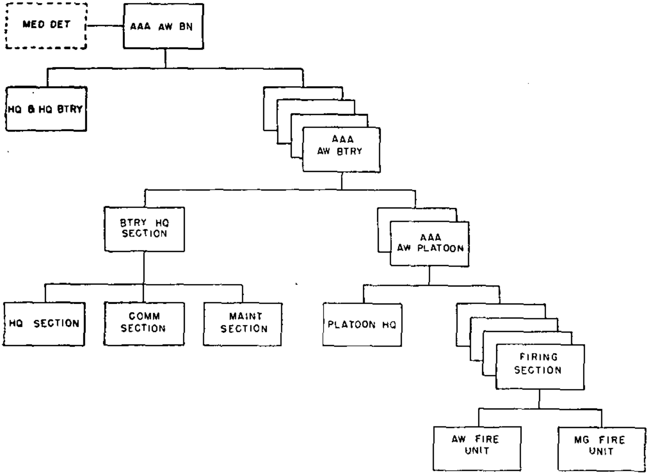

Figure 1. Organizational chart of the mobile automatic weapons battalion.

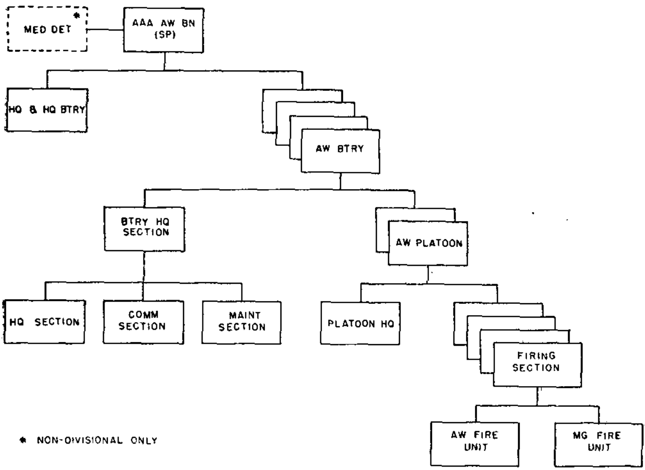

Figure 2. Organizational chart of the self-propelled automatic weapons battalion.

quarters battery and four self-propelled firing batteries (fig. 2). The self-propelled automatic weapons battalion organic to division does not have a medical detachment.

c. Airborne automatic weapons battalion and medical detachment. The battalion consists of a headquarters and headquarters battery and three automatic weapons firing batteries (fig. 3).

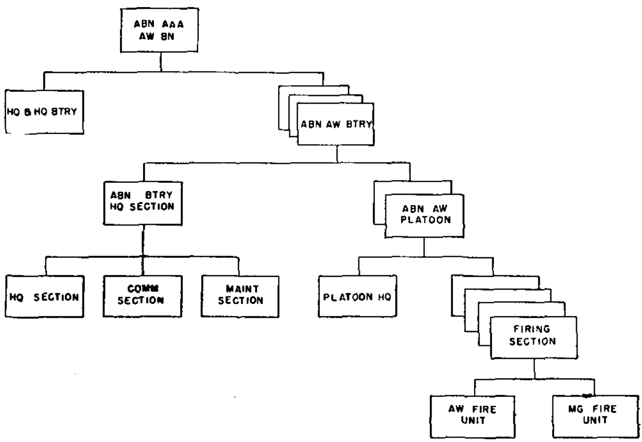

Figure 3. Organizational chart of the airborne automatic weapons battalion.

7. BATTALION COMMANDER. a. The battalion commander is responsible for the tactical employment of the elements of his command and for training, administration, and supply. He is informed of priorities for antiaircraft artillery defense and, by consultation and liaison with higher headquarters, keeps informed of the general situation and contemplated movements. In addition, he esti-

mates the probable future situation based on the information available and prepares tentative plans for the employment of his unit.

b. The elements of his battalion may be scattered widely for long periods of time. To maintain efficiency he must make frequent inspections covering all phases of activity engaged in by elements of his command.

c. The battalion commander must keep his battery commanders advised of the friendly and enemy situation so far as it affects the performance of their mission. He gives such instructions regarding fire direction as the situation warrants and directs changes of position, when necessary. He supervises the supply of ammunition and other supplies to the batteries.

d. In other than the division area, if the antiaircraft artillery defense does not include antiaircraft artillery guns, the automatic weapons commander is responsible for the establishment and operation of the Antiaircraft Operations Center (AAOC) and Antiaircraft Artillery Intelligence Service (AAAIS). The personnel to operate the AAOC normally will be obtained from the operations section and communication section of the battalion headquarters battery. The automatic weapons battalion organic to division will not establish an AAOC. Refer to FM 44–8 for detailed information on the AAOC and the AAAIS.

e. When an automatic weapons battalion is part of a coordinated antiaircraft artillery defense, it

will contribute information for the AAAIS. The battalion AAAIS personnel includes all AAA observers and radar personnel of the defense that are in communication with the AAOC.

f. When the battalion commander is the senior artillery officer with a force, it is his responsibility to advise the force commander on antiaircraft matters.

8. BATTALION STAFF. The battalion staff members assist the battalion commander by providing basic information and advice. They develop details of the commander's plan, translate the plan into orders, transmit tentative plans, and secure unity of action throughout the command. To insure unity of action, the staff members assist and advise the battery commanders, whenever possible. For detailed study of the duties of various staff officers, refer to FM 101–5.

Section III. CHARACTERISTICS OF EQUIPMENT

9. GENERAL. a. The fire of antiaircraft artillery automatic weapons differs from the fire of the larger caliber guns which use a time fuze; the automatic weapons projectiles must actually hit the aircraft or operating personnel to be totally effective. The 40-mm gun uses a shell with a supersensitive fuze which bursts on contact or, if no contact is made, destroys the projectile at the tracer burn-out range. There is a deterrent effect upon piloted enemy aircraft when the fire is extremely close, but to be truly effective the projectile must hit the target.

b. Automatic weapons have a flexibility that enables them to follow aircraft at a high angular rate and to shift quickly from one target to another. These factors and the great volume of fire which automatic weapons can deliver make them the most effective ground weapons against low flying aircraft.

c. Self-propelled antiaircraft artillery automatic weapons (M16 and M19) have great road mobility and are desirable weapons to use with combat forces. The 40-mm gun and the M55 multiple machine-gun mount have less mobility and are dependent upon prime movers for movement; they are suitable for employment in situations where there is more time for such displacements as may be necessary.

10. AMMUNITION. a Classes. The principal classes of combat ammunition for the caliber .50 machine gun are ball, armor piercing, incendiary, armor piercing-incendiary, and tracer. The 40-mm gun uses high explosive and armor piercing shot. The tracer element of caliber .50 ammunition burns out at a range of about 1,850 or 2,450 yards, depending on the type. The 40-mm high explosive and the armor piercing shot contain a tracer element; the high explosive shell destroys itself at the tracer burn-out point which varies from 3,500 or 5,500 yards, depending on the type.

b. Uses. The uses of the various types of ammunition are as follows:

(1) Caliber .50 ammunition and the 40-mm high explosive shell are used against personnel and light matériel.

(2) Caliber .50 and 40-mm armor piercing ammunition are for use against lightly armored vehicles, concrete shelters, and similar penetration resisting targets.

(3) Caliber .50 incendiary ammunition is for use against inflammable or explosive targets.

(4) Caliber .50 tracer ammunition and the tracer element of the 40-mm ammunition are primarily for observation of fire.

(5) All types of automatic weapons ammunition are employed against aerial targets.

11. RANGE LIMITS OF AUTOMATIC WEAPONS ANTIAIRCRAFT FIRE. There are four range limits of automatic weapons fire. They are as follows:

a. Extreme deterrent range.

(1) Extreme deterrent range is the tracer burn-out range of automatic weapons projectiles. Fire at this range is not accurately aimed fire and cannot be expected to make any given round a hit.

(2) Deterrent fire delivered at extreme ranges, and with maximum density, can decrease the efficiency of operation of enemy aircraft by making them break formation, take evasive action, and, in some cases, cause them to abandon their mission.

(3) The extreme deterrent ranges of automatic weapons are—

(*a*) Caliber .50 machine guns—1,800 or 2,450 yards (dependent upon type of ammunition).

(*b*) 40-mm gun—3,500 or 5,500 yards (dependent upon type of ammunition).

b. Maximum hitting range.

(1) The maximum hitting range is the longest range, under average conditions, that the various weapons and methods of fire control can produce hits.

(2) The maximum hitting range depends on the visibility of tracers when tracer observation is used for fire adjustment, on the approach angle of the target, on the speed of the target, and on the type of fire control employed. The director controlled 40-mm gun can deliver aimed fire when the longest range is set on the director. This range setting can produce a hit at about 2,500 yards range. On-carriage fire control offers a less accurate means of tracking and fire adjustment is dependent on tracer observation. In this case, maximum hitting range is the longest range at which tracers can be interpreted. Experience has shown that the longest ranges of the various weapons fall in the following limits:

Caliber .50 machine gun — 1,000 yards

40-mm gun—1,800 yards.

c. Effective hitting range.

(1) Effective hitting range is the range with-

in which weapons can execute effective fire and hits can be expected. It forms the basis for doctrines concerning tactical employment of automatic weapons.

(2) Effective hitting range depends mainly on across-course aiming tolerance and the fire control equipment employed. Across-course aiming tolerance is defined as one-half the mil angle subtended at the gun by the depth of the target. The actual physical size of the target causes the target to subtend a greater angle at the gun at close ranges than it does at distant ranges. Therefore, there is more aiming tolerance at close ranges. The target must be close enough so that the tracer sensings are fresh and reliable.

(3) Effective hitting range for a particular weapon and fire control device varies with the target speed, angle of approach, and the state of training. The average effective hitting ranges are as follows:

(*a*) Caliber .50 machine guns—800 yards.

(*b*) 40-mm gun:
On-carriage control—1,200 yards
Off-carriage control—2,000 yards.

d. Minimum midpoint tracking range.

(1) Minimum midpoint tracking range is the smallest midpoint range at which gun pointers can continue to track close-in targets; it is a variable dependent upon target speed and maximum tracking rate

of the mount concerned. As the angle of approach of such targets increases, the angular rate of travel may be so great as to make tracking inaccurate or impossible.

(2) The power operated caliber .50 machine-gun turret mounts have virtually no minimum range limitations.

(3) The 40-mm gun with director is incapable of dealing with high-speed, close-in targets at less than 400 yards slant range.

(4) The gun motor carriage M19 generally is incapable of dealing with high-speed, close-in targets at less than 300 yards slant range.

12. WEAPONS. a. 40-mm gun. The 40-mm gun is either fully automatic or semiautomatic; it can deliver short bursts at the rate of 120 rounds per minute. It is air-cooled and, if fired at the maximum rate, may begin to overheat after firing about 100 rounds. When overheated, the firing must be suspended and the barrel changed (30–40 seconds). For tactical planning of fields of fire, a horizontal range of 1,500 yards is used. However, when using the director, firing is not effective at ranges of less than 400 yards because of mechanical limitations of the range finder. The gun will elevate from $-6°$ to $+90°$ and will traverse through $360°$.

b. Caliber .50 machine gun. The caliber .50 machine gun fires at the rate of 400 to 600 rounds

per minute. Its effective range is dependent primarily upon the gunner's depth perception. For tactical planning of fields of fire, a horizontal range of 600 yards is used. The standard mount for the caliber .50 machine gun is an electrically operated, multiple gun mount. These multiple mounts can be traversed and elevated at maximum rates of 60° per second by a single operator.

13. TOWED MOUNTS AND CARRIAGES. a. 40-mm gun on carriage M2A1. The 40-mm gun on carriage M2A1 (fig. 4) is used in mobile units. The time required to emplace the carriage from traveling position and to commence firing (using direct fire sights) is 1 to 2 minutes. To emplace the director and prepare the unit for director-controlled fire requires considerably more time (5 to 30 minutes, dependent on terrain).

b. Multiple machine-gun mount M45 (fig. 5).

(1) The multiple machine-gun mount M45 is a caliber .50 machine-gun fire unit of four guns. The gunner occupies an adjustable seat within the mount and directs his aim with either a Mark IX or an M18 sight. The guns and ammunition are mounted outboard of the mount trunnions. The power unit is suspended below the turntable of the mount and travels with it in azimuth. The power unit has a variable speed drive that produces azimuth and elevation rates from zero to maximum speed in both directions.

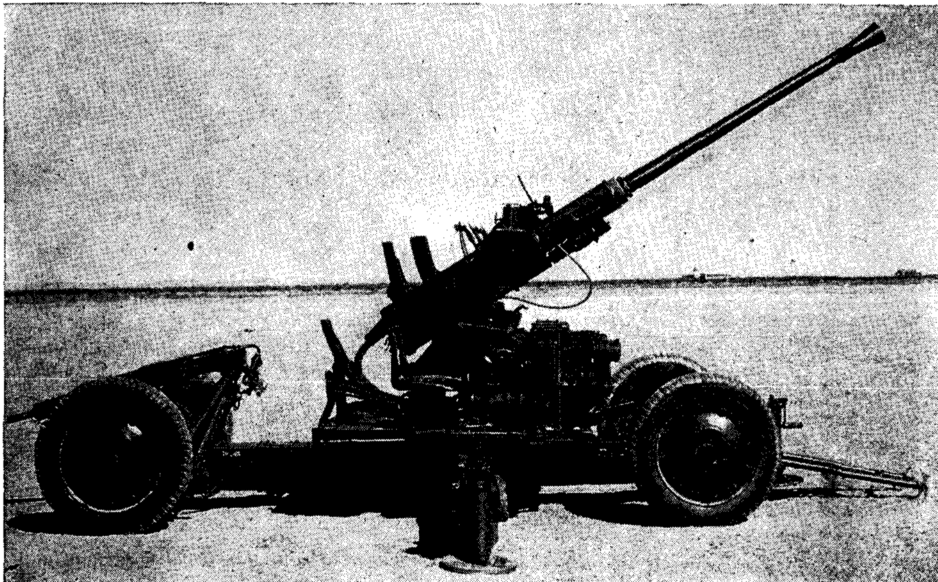

Figure 4. 40-mm gun on carriage M2A1.

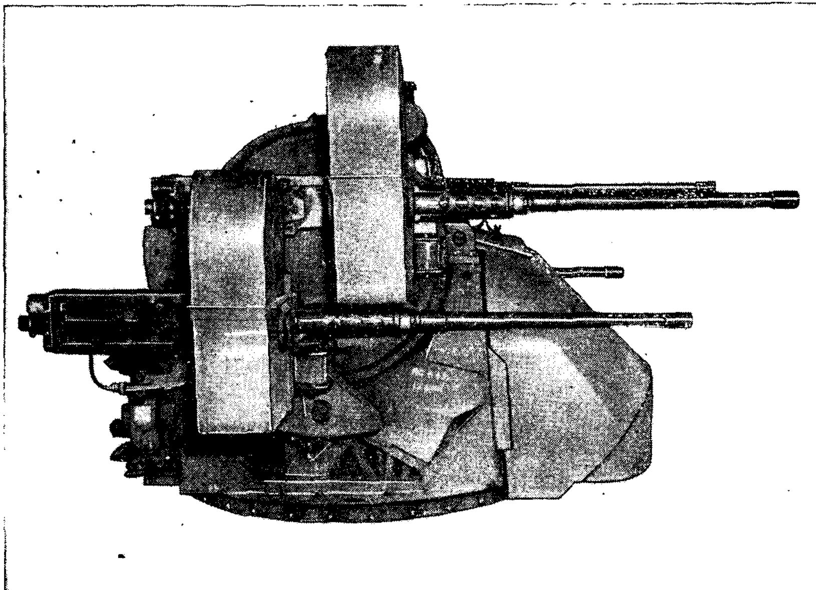

Figure 5. Multiple machine-gun mount M45.

(2) The machine guns on the M45 mount are fired by means of solenoids; these solenoids are electric coils mounted on the back plate buffer tubes of each gun.

(3) The maximum tracking rate in both azimuth and elevation is 60° per second.

c. Multiple machine-gun trailer mount M55 (fig. 6). The multiple machine-gun trailer mount M55 is used in mobile and airborne units. The mount is transported in a 2½-ton cargo truck. The mount may be loaded in conventional type troop carriers and gliders without disassembly. The mount must be emplaced prior to firing. The time required for emplacement is from 1 to 2 minutes. The mount can be man-handled for short distances. The turret in this trailer mount is the M45.

14. SELF-PROPELLED CARRIAGES. a. Multiple gun motor carriage M16 (fig. 7). The multiple gun motor carriage M16 is a multiple machine-gun mount (M45) installed in a half-track vehicle. Fire to the front of the vehicle is restricted at low elevations because of the vehicle cab and driver compartment.

b. Twin 40-mm gun motor carriage M19 (fig. 8). The twin 40-mm gun motor carriage M19 has two 40-mm guns mounted coaxially on a full-track vehicle.

15. FIRE CONTROL EQUIPMENT. a. On-carriage sights. There are two general types of on-carriage

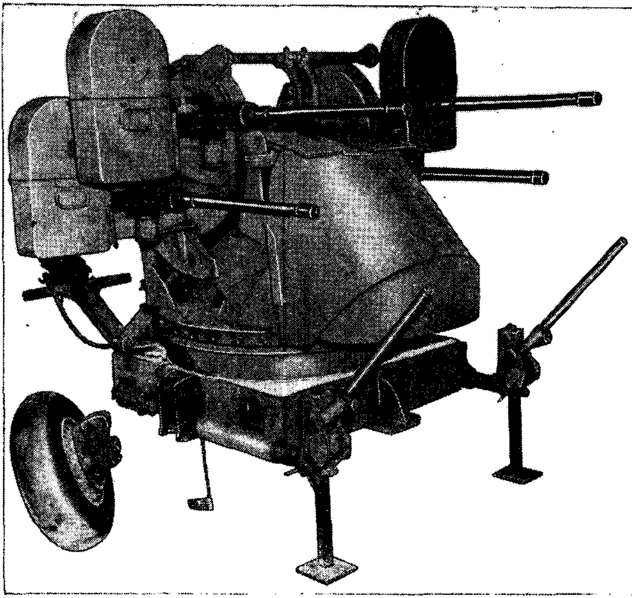

Figure 6. Multiple machine-gun trailer mount M55.

sights—speed ring sights and computing sights.

(1) *40-mm speed ring sights.*

(*a*) The speed ring sights issued as an auxiliary fire control system to the computing sight M13 consists of a front element of eight speed rings and a rear element with a small circular peep sight. The eight speed rings represent required midpoint leads for targets traveling 25, 100, 200, 300, 400, 500, 600, and 700 miles per hour at a midpoint range of 1,000 yards (fig. 9).

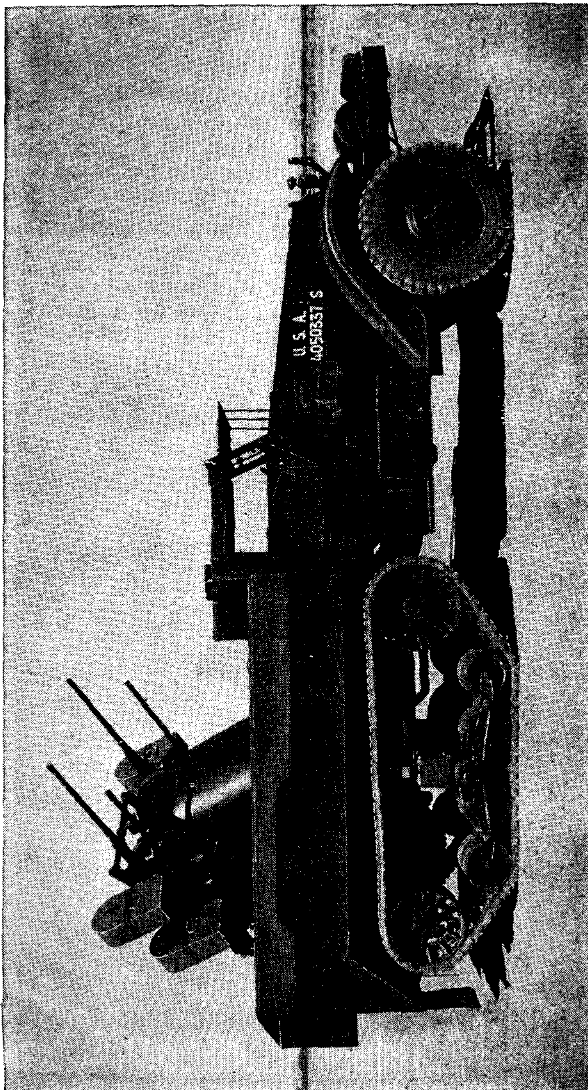

Figure 7. Multiple gun motor carriage M16.

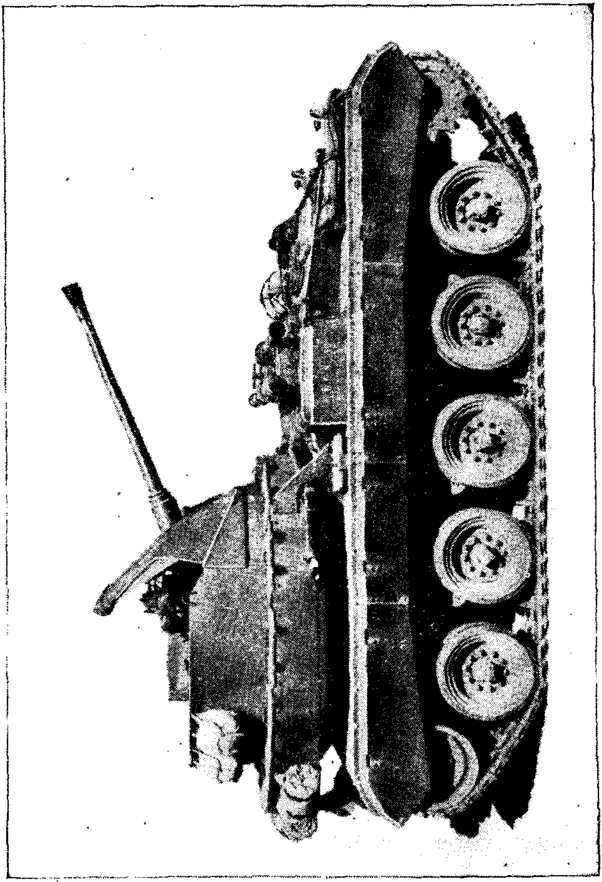

Figure 8. Twin 40-mm gun motor carriage M19.

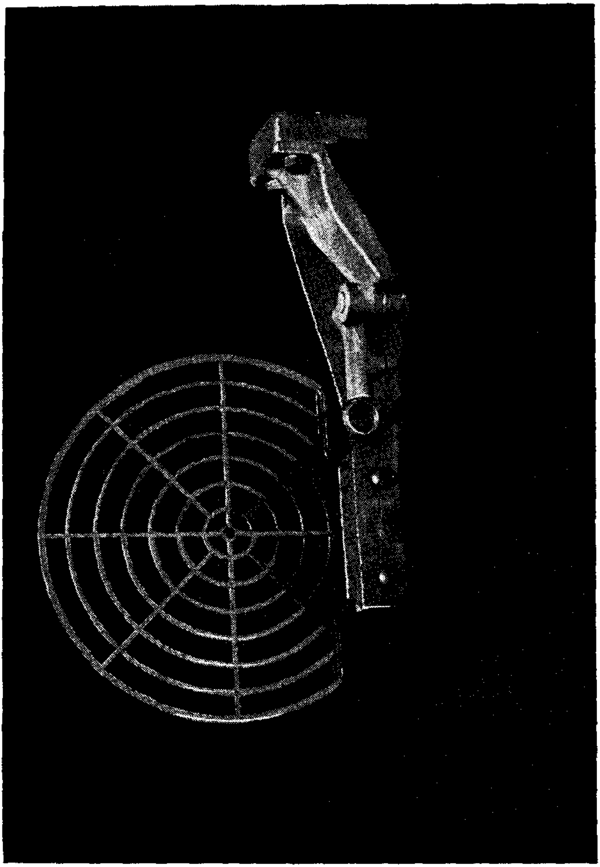

Figure 9. Speed ring sight used as an auxiliary sighting system to the M13 computing sight.

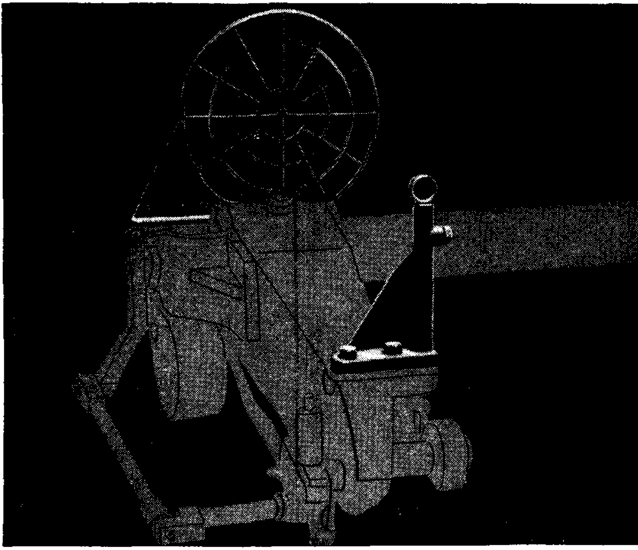

Figure 10. Speed ring sight used as an auxiliary sighting system to the computing sight M7A1.

(*b*) The speed ring sight issued as an auxiliary fire control system to the computing sight M7A1 consists of a front element of four concentric rings and three pips and a rear element containing a small circular peep sight (fig. 10). The four rings represent the required midpoint leads for targets traveling at speeds of 100, 200, 300 and 400 miles per hour. The pip on the vertical wire is used to establish the fixed value of super-elevation during orientation. The two pips on the horizontal wire represent the required

midpoint leads for a 20 miles per hour target and are used for fire against moving land and naval targets.

(2) *Navy Mark IX sight* (fig. 11). The Navy Mark IX reflector sight is a speed ring sight which projects a sharp image of a reticle into the field of view of the gunner. The gunner, by looking through the sloping plate of glass, sees the target and the reflection of the sight reticle. Thus, the gunner sees both images superimposed—one through the sloping pane, the other reflected from the sloping plate. They are both in sharp focus and appear at the same distance. An electric bulb is used to illuminate the reticle. The sight reticle has a bright dot in the center and two concentric rings. The two concentric rings represent the required midpoint leads for speeds of 50 and 100 miles per hour. Greater leads are applied by extrapolating beyond the field of view of the sight.

(3) *Computing sight M7.*

(*a*) The computing sight M7 (fig. 12) is an on-carriage sighting device. Its mechanism contains a small replica of the basic slant plane triangle, T_oGT_p, illustrated in figure 13. The assembly consists of a main support bar, a deflection mechanism control case, two M7 telescopes (and ring sights), an

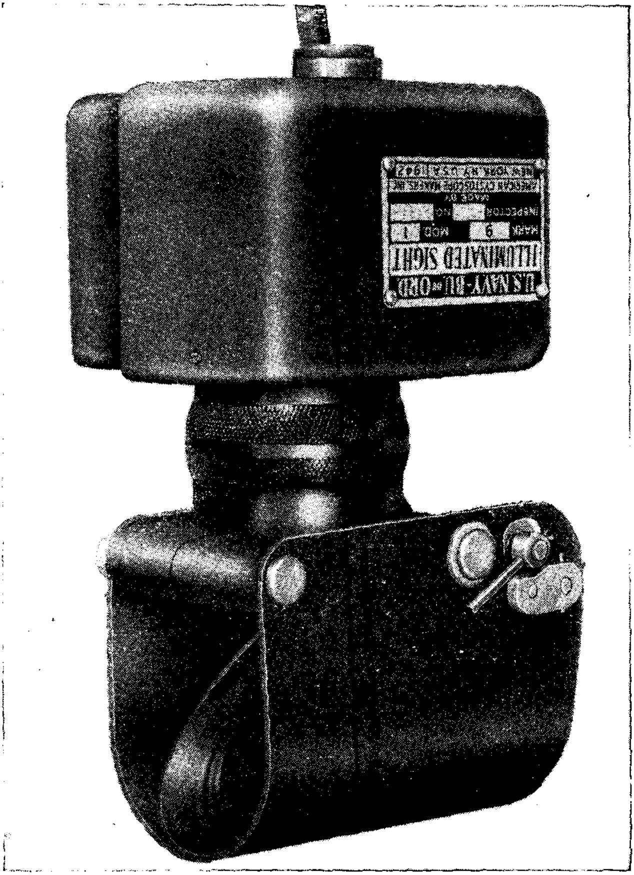

Figure 11. Navy Mark IX reflector sight.

azimuth gear box, an adapter for the gun elevation limit switch, and various linkages and drives.

(*b*) An arrangement of parallel linkages keeps the deflection control box level

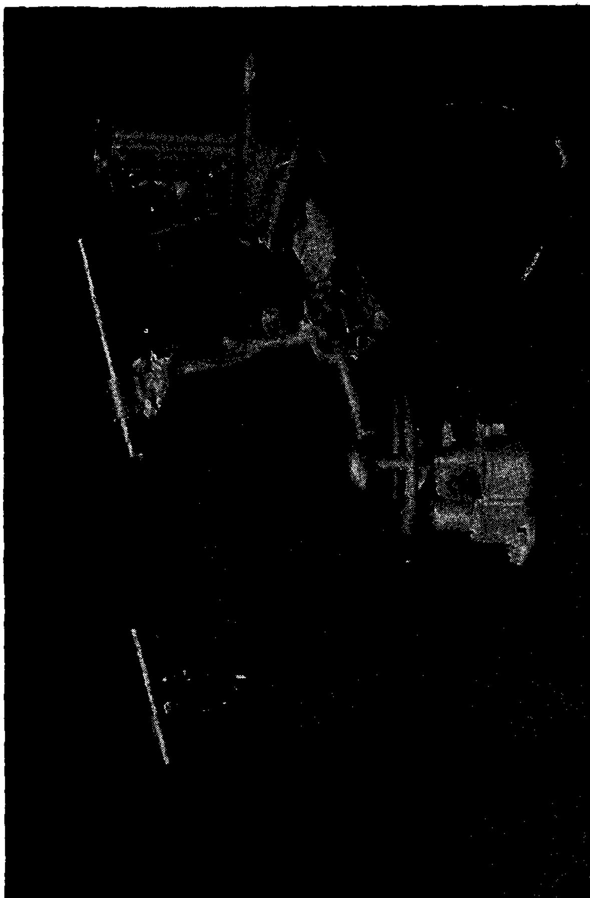

Figure 12. Computing sight M7.

as the gun is moved in elevation. A target course arrow, mounted on top of the deflection mechanism control case, aids in locating the deflection mechanism in the slant plane. A speed dial in the deflection mechanism control case, graduated in 25-mile-per-hour divisions from 0 to 500 miles per hour, indicates the lead angle setting in terms of target speed. The deflection mechanism is operated by a lead setter.

(*c*) *Sights.*

1. *Telescopes.* In each telescope, one cross hair is unbroken; the other cross hair is broken at the center. The elevation telescope is installed with the unbroken cross hair horizontal. The azimuth telescope is installed with the unbroken cross hair vertical.

2. *Auxiliary ring sights.* The auxiliary ring sight is designed to increase the efficiency of the sighting system by providing a means of tracking when it is impractical to track with the telescopes. The auxiliary ring sight is more accurate than the telescopes only when the telescopes fog or when firing rocks the mount so as to make tracking with the telescopes impossible. The front element of the elevation auxiliary ring sight contains

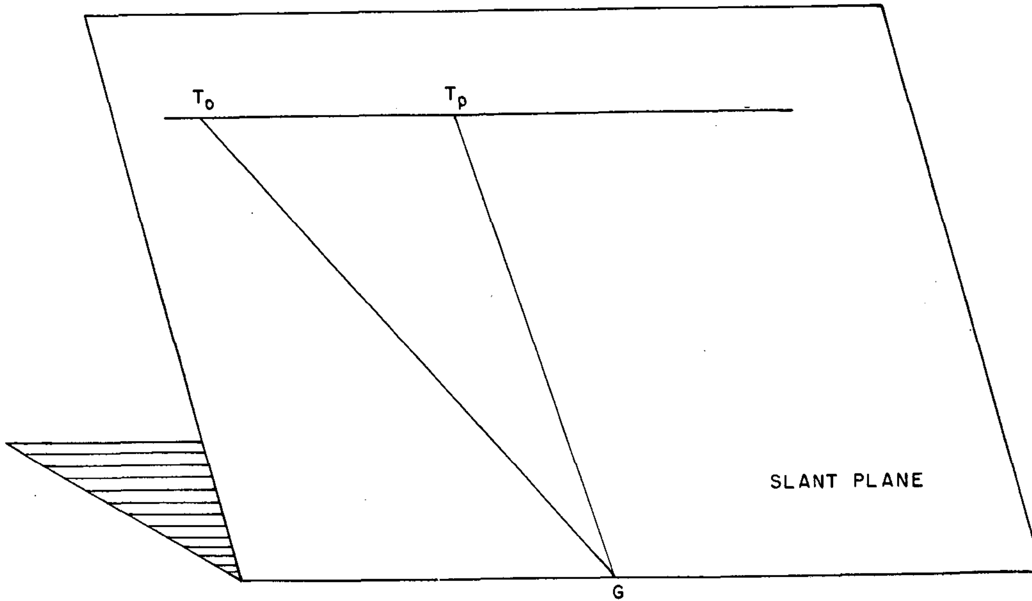

Figure 13. Slant plane triange, T_oGT_p.

a single horizontal diametrical wire. The front element of the azimuth auxiliary ring sight contains a single vertical diametrical wire.

(4) *Computing sight M13.* The computing sight M13 is an on-carriage course and speed type computing sight, designed for use on the gun motor carriage M19. It is similar in principle to the M7 computing sight. It is capable of computing for target speeds up to 500 miles per hour. Two sets of controls for adjusting the course arrow and speed are provided; the lower set may be used when the mount is operated at power control thus taking advantage of the armor plating, and the upper set is used when the mount is at manual control. Two reflex sights, one for each tracker, make target pick-up and tracking much easier and more accurate; these reflex sights are daylight illuminated but have artificial illumination for use under conditions of reduced visibility (fig. 14).

(5) *Computing sight M19.* The computing sight M19 is an on-carriage course and speed computing sight designed to replace the M7 computing sight. It is similar in principle to the M7 except that it can compute for a diving or climbing target. It was designed for the towed 40-mm gun and is located so that the sight operator is out of the way of either

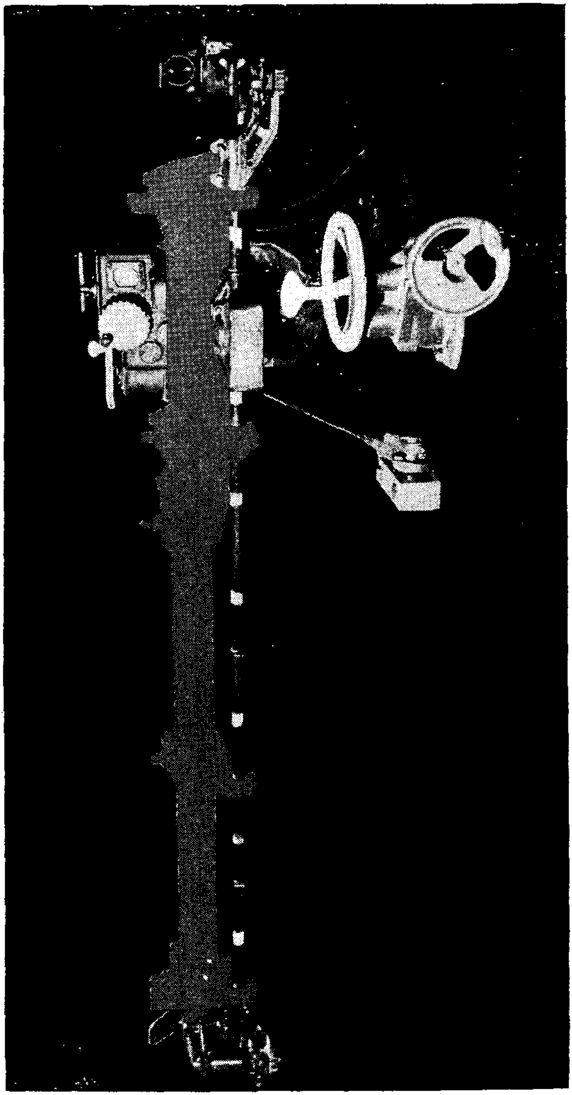

Figure 14. Computing sight M13.

tracker. Two reflex sights are provided, one for each tracker; these sights are daylight illuminated, but have artificial illumination for use under conditions of reduced visibility (fig. 15).

(6) *Reflex sight M18.* This sight is an improvement of the Mark IX reflex sight and operates on the same principle. Its advantage over the Mark IX sight is that it has additional speed rings. It is designed for the multiple machine-gun mount M45. The reticle image has four concentric circles which correspond to midpoint leads for speeds of 100, 200, 300 and 400 miles per hour, and three dots in a vertical line in the center of the field of view. The upper dot is for orienting and introduces about 10 mils superelevation. Orienting on the middle dot introduces about 5 mils superelevation. The lower dot is the center of the concentric circles and is used during tracking as the hub toward which the target is pointed. The M18 sight is daylight illuminated and has artificial illumination for use during periods of reduced visibility (fig. 16). (See FM 44–57 for details of operation.)

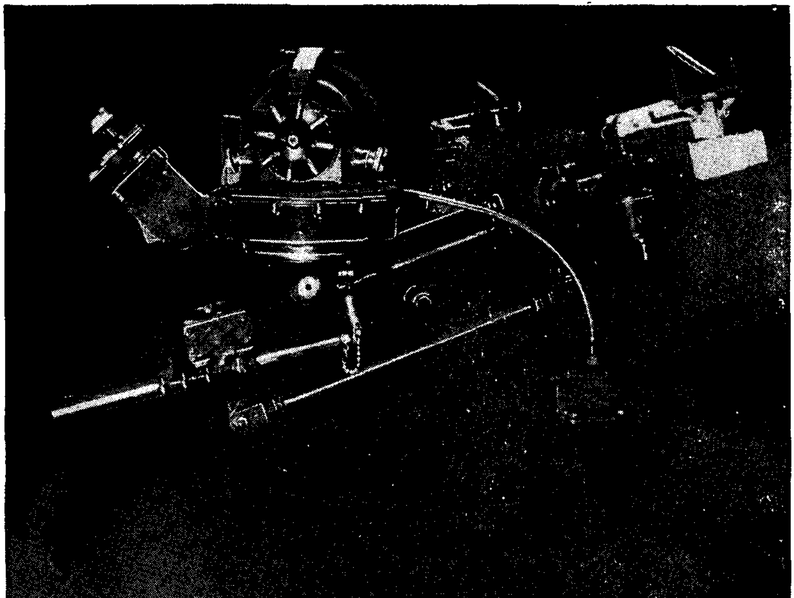

Figure 15. Computing sight M19.

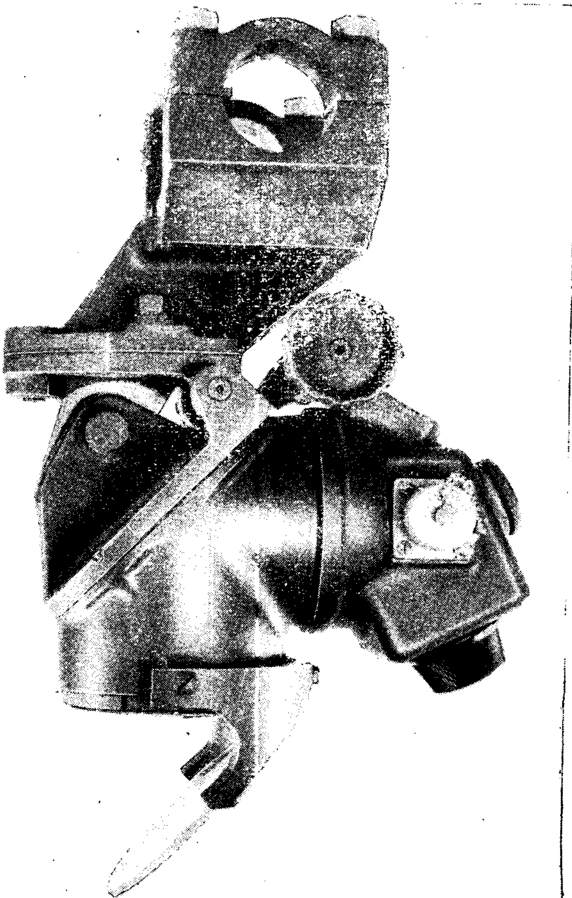

Figure 16. Reflex sight M18.

b. Off-carriage fire control.

(1) The M5 type director provides the primary method of fire control for the 40-mm gun on the M2A1 mount. There are four types of M5 directors:

(*a*) M5 director, basic design, using torque amplifiers. It operates on 115-volt, 60-cycle power.

(*b*) M5A1 director, a modification which contains gear trains to replace the torque amplifiers; and a coarse data transmitter in elevation to make the gun fully self-synchronous both in azimuth and elevation when used with the M3 oil gear.

(*c*) M5A2 director, essentially identical with the M5A1 with the addition of a 30-inch coincidence range finder.

(*d*) M5A3 director, identical with M5A2 except that its traversing rate is increased to 30° per second (fig. 17).

(2) The basic director and its modification uses the rate-range principle of prediction. The tracking telescopes measure the instantaneous time rate of change of azimuth and elevation. These rates are multiplied by a selected time of flight of the projectile to establish leads. Remote control system M5 using the M1 oil gear or remote control system M15 using the M3 oil gear, transmits electrical data signals to the gun. The oil gear units lay

the gun in firing azimuth and quadrant elevation continuously in accordance with the leads established by the director.

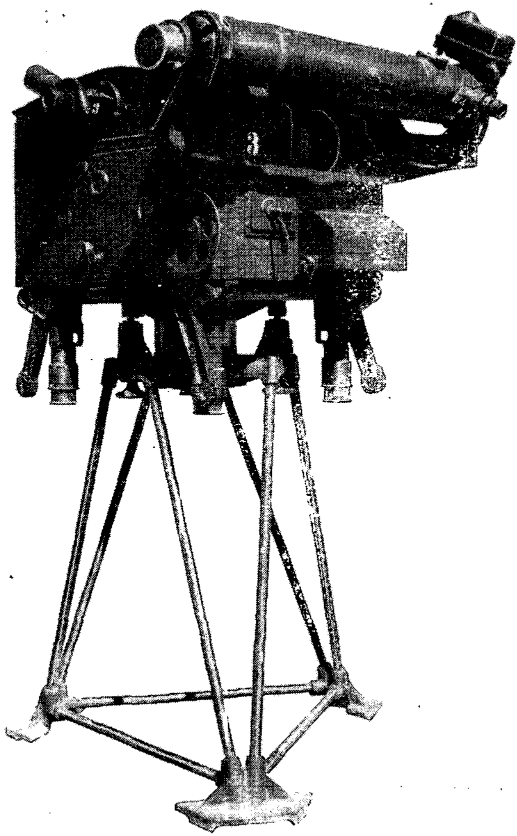

Figure 17. Director M5A3.

(3) The director provides the following advantages over on-carriage sights in forging the links of the gunnery chain:

(*a*) Director fire control can be used effectively on targets at longer ranges.

(*b*) The director is at a small distance from the gun. This reduces disturbances of trackers due to noise, smoke, and vibration during firing.

(*c*) Director fire control can be made to be largely independent of tracer observation.

(*d*) The rules for director fire control are the same regardless of the direction of the target's course.

(4) Since the M5 director is located only 13 feet from the gun, it is obvious that fire cannot be placed over the director at low elevations. For tactical planning, a dead area of 70° is established in the horizontal plane; the gun-director line is the bisector of this dead area (fig. 18). The force commander, on recommendation of the antiaircraft commander, determines the dead area in the vertical plane; it is normally 30°.

Section IV. EMPLOYMENT

16. NATURE OF EMPLOYMENT. a. General. Antiaircraft artillery automatic weapons may be employed in moving situations with ground combat

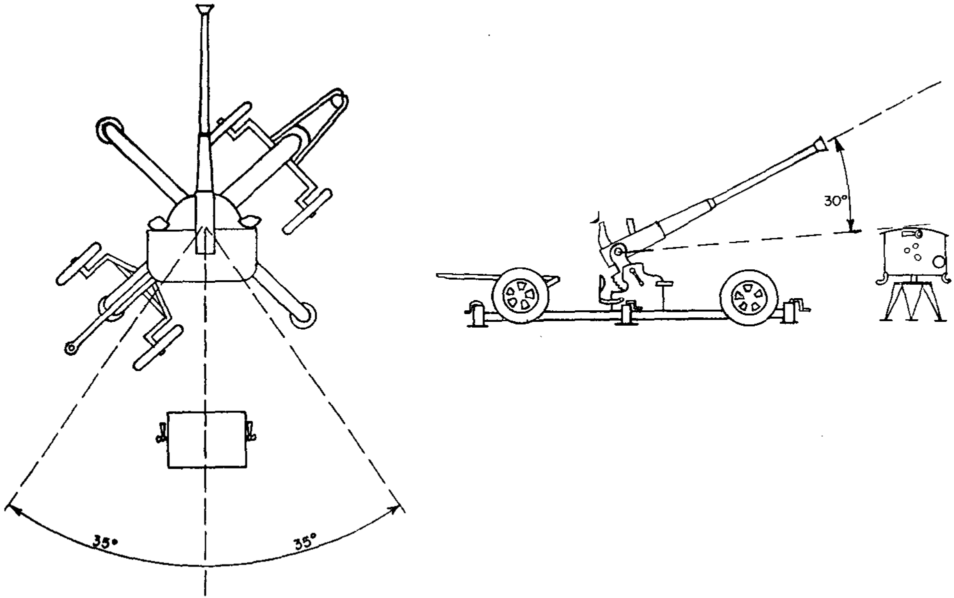

Figure 18. Dead area of the 40-mm gun with director M5A2 or M5A3.

forces or in rear areas in defense of permanent or semi-permanent installations. Mobile or self-propelled units have sufficient transportation to move all the fire units simultaneously.

b. Employment in rear areas. The term employment in rear areas is used to describe the anti-aircraft artillery defense of permanent or semi-permanent installations. Depending on the situation, automatic weapons may be employed in the combat zone, the communication zone, or the zone of interior.

c. Employment in forward areas. The term employment in forward areas is applied to antiaircraft operations with ground combat troops in contact with the enemy.

17. ELEMENTS AFFECTING EMPLOYMENT. a. Tactics of the enemy. Following are the types of attacks that the enemy can be expected to employ against installations protected by automatic weapons:

(1) *Dive attack.* Dive bombing is employed against precision targets and is an accurate method of bombing. The pilot dives the aircraft directly at the target and releases the bomb just prior to pulling out of the dive. The pull-out is usually 1,000 to 5,000 feet above the ground. The angle of dive is normally 50° to 80°. Dive bombing attacks may be expected from any direction; however, the position of the sun, a protecting cloud bank, the terrain, or the time of day are influencing factors.

(2) *Minimum altitude attack.* Minimum altitude attacks are directed against personnel and ground installations. They may include strafing, skip bombing, torpedo launching, mine laying, and chemical attack. This type of attack is a common one against which the antiaircraft automatic weapons must defend. In a minimum altitude attack the pilot stays as close to the ground as the terrain will permit, flying at altitudes of 15 to 200 feet. He takes advantage of protection afforded by hills, trees, and buildings. Surprise is the pilot's greatest advantage, so he tries to reach the objective unobserved.

(3) *Low-level horizontal flight attacks.* Low-level horizontal flight attacks are those bombing attacks on which the aircraft flies a level course within range of automatic weapons. This type of attack is not common because it lacks surprise and the plane is more likely to be shot down. Low-level horizontal flight targets may include some types of rockets or jet-propelled flying bombs.

(4) *Air-to-surface glide or jet-propelled bomb attack.* This type of attack implies that a glide or jet-propelled bomb will be released from an enemy aircraft which does not come within range of the defending automatic weapons. Since the

releasing aircraft cannot be destroyed, the obvious defense is to knock down the glide or jet-propelled bomb.

(5) *Surface-to-surface guided missile.* In this type of attack, the missiles probably would be released from well protected positions behind the enemy lines. The defense, as far as antiaircraft artillery is concerned, depends on shooting down these missiles before they reach the objective. Since the present trend in surface-to-surface guided missiles seems to be propelling them at supersonic speeds through the upper regions of the atmosphere and allowing them to descend almost vertically upon the target, it is hardly feasible to look on them as automatic weapons targets. If low-level horizontal flight missiles of subsonic speed are used, they will be suitable targets for automatic weapons and will be engaged in the same manner as aircraft flying a similar type course.

(6) *Pilotless aircraft.* This type of attack may be made by a radio-controlled aircraft, most likely guided by a motherplane in the distance. The attack consists of either crashing the pilotless aircraft into the target or having it dump its bombs by radio control. In either case the automatic weapons defense is to shoot down the aircraft before it reaches the objective.

(7) *Determining the type of attack.* The following factors determine the type of attack adopted by the enemy:

(*a*) Capabilities, limitations, and number of aircraft available.

(*b*) Distance of airdromes from objective.

(*c*) Local air superiority.

(*d*) Estimate of the antiaircraft defense.

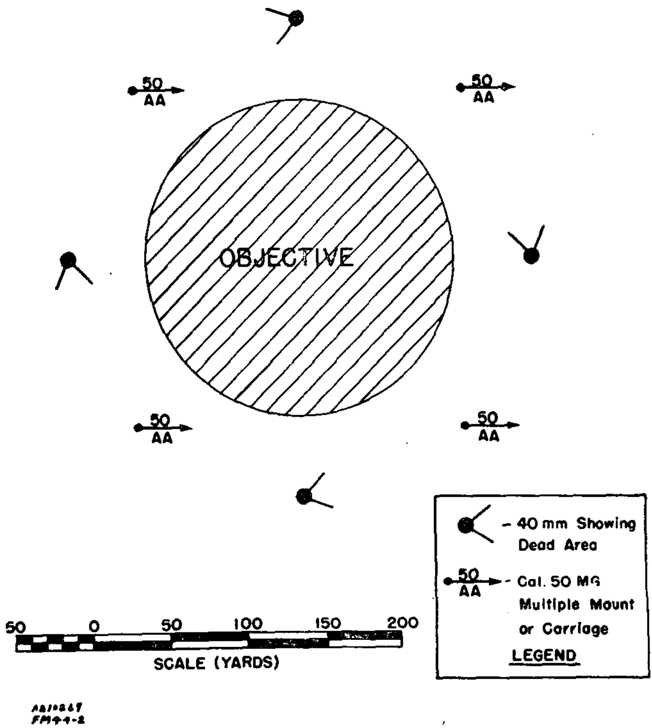

Figure 19. Defense of a single objective.

(*e*) Weather (visibility, cloud formations, and position of sun).

(*f*) Size, shape, and nature of objective; terrain in vicinity.

(*g*) Importance of objective to accomplishment of mission.

(*h*) Prevailing winds; in areas of prevailing winds, it is expected that enemy planes will attack down wind so that their ground speed will be increased, and their time over the objective reduced to a minimum.

b. The type of objective.

(1) *Single objective.* A single objective is any objective which is 500 yards or less in diameter. Factory buildings, distributing points, a bridge, or a field artillery battery in position are examples of single objectives (fig. 19).

(2) *Vital area.* A vital area is any objective which has a diameter of more than 500 yards. It may be a group of single objectives separated by not more than 1,500 yards, or it may be one large objective. If this group of single objectives is separated by more than 1,500 yards, it normally will be more economical to defend each as a single objective. Examples of vital areas are a number of field artillery batteries in an artillery area; a scattered group of factory buildings; a railroad

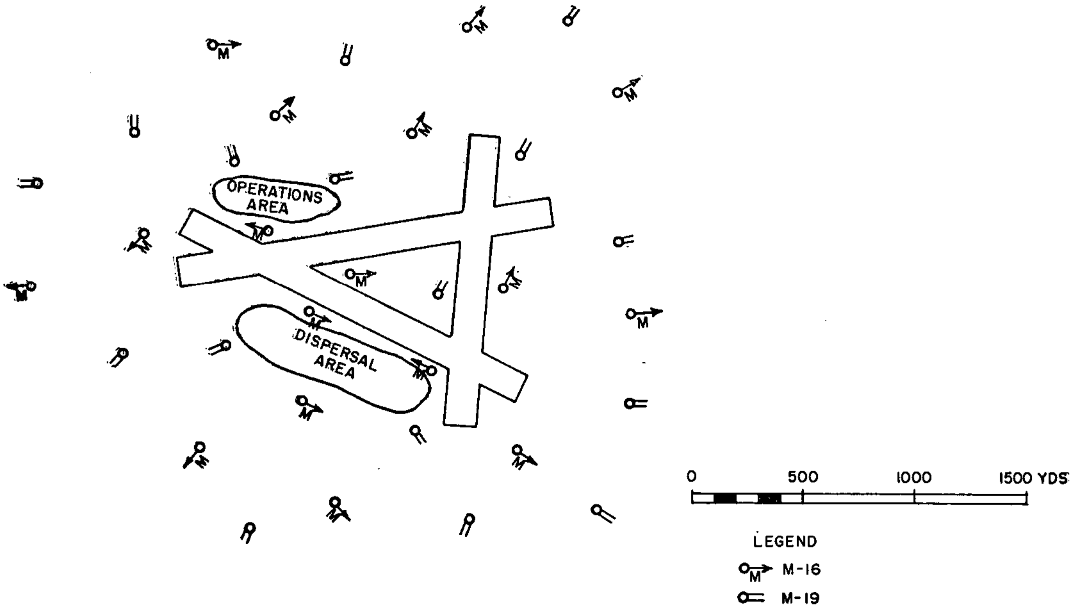

Figure 20. Defense of a vital area.

marshalling yard; or an airfield, including the dispersal areas, repair shops, bomb dumps, operations buildings, and landing strips (fig. 20).

(3) *Shape of objective.* To some extent the shape of the objective dictates the direction of attack. A generally compact target can be attacked from any direction. However, to effectively strike a long, narrow target, low-flying aircraft must make a bomb run along a line forming a reasonably small angle with the long axis of the target (fig. 21).

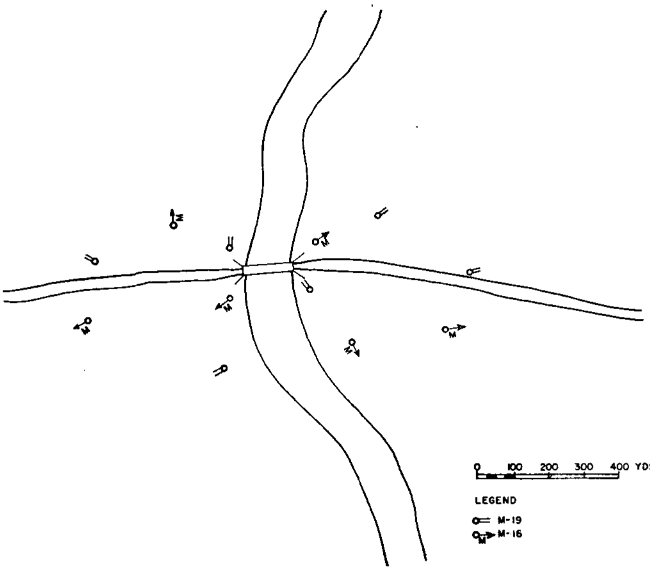

Figure 21. Effect of the shape of an objective on the defense of that objective.

c. Terrain. Terrain is a very important consideration in planning an automatic weapons defense because it often influences the enemy's choice of type and direction of attack.

(1) In low-level attacks, the pilot has to see the objective for some seconds before he can attack successfully. This period of approach and sighting varies from 2 to 10 seconds. Therefore, in this type of attack, the enemy pilot must choose a direction of attack that gives him the desired visibility.

(2) Since terrain does influence the direction of attack, it will define certain logical avenues of approach. Special emphasis must be given these avenues of approach when planning the defense.

(3) Probable avenues of approach also are influenced by the following:

(*a*) An attacking aircraft will try to avoid adjacent defended areas.

(*b*) Pilots may be expected to exploit approaches over water, woods, or any other terrain features that indicate a poorly defended area.

(*c*) Navigation of aircraft is extremely difficult at low altitudes, and pilots use landmarks such as roads, railroad tracks, rivers, and bridges to aid themselves in locating the objective. The presence of any such landmark indicates a possible avenue of approach.

(4) The attacker, as far as is practicable, takes advantage of the terrain to conceal his approach.

18. BASIS FOR EMPLOYMENT. The capabilities and limitations of automatic weapons, as well as the elements affecting their employment, must be considered in planning a defense.

a. Defense against dive bombing. In this type of attack, the enemy aircraft can be engaged most effectively by weapons sited at the objective. The gunnery and fire control problems are simplified since the aircraft flies almost down the barrels of those guns facing the attack. Simple coming courses are presented. From a practical standpoint it must be considered that weapons located at the objective are likely to be bombed with the objective and put out of action, and that dust, dirt, and debris resulting from the bombing may obscure the vision of the crews. For defense against dive bombing attack, weapons should be sited on or as close to the objective as practicable after consideration of the advantages and disadvantages as outlined above. If the defended area is more than 600 to 800 yards wide, some weapons should be sited within the defended area.

b. Defense against minimum altitude attack. The high rates of angular travel required to track fast crossing targets, with mid-point ranges of less than 400 yards, are beyond the capabilities of the 40-mm gun. Therefore, these weapons are sited near the objective or along probable avenues of

approach so that the targets in their field of fire are likely to be incoming. The multiple mount caliber .50 machine guns have the ability to track rapidly, and can engage high speed targets on close-in, crossing courses. Machine guns also have a high rate of fire and are, therefore, effective weapons to defend against this type of attack. The range of the machine gun is relatively short and to be effective the gun must be emplaced near the path of the attacking plane. Since the direction of attack cannot be predicted, some machine guns are placed near the objective in order to insure that machine-gun fire can be placed on any attacking plane.

c. Defense against low-level horizontal flight attack. To defend against low-level horizontal flight attack, weapons are sited at a sufficient distance from the objective to insure that fire can be placed on the plane before the bombs are released. Because of its large projectile and greater effective range, the 40-mm gun is generally more effective against such attack. Low-level horizontal flight attacks are not common and normally are not considered until reasonable protection against dive bombing and minimum altitude attacks have been provided. Protection against low-level horizontal flight attack then is provided incidental to the extension of the defense outward in depth along the known or expected avenues of approach. When rocket or jet-propelled missiles are used the defense is deepened by additional automatic weapons.

19. SITING OF WEAPONS. a. In order to obtain massing of fire and to secure the maximum num-

ber of incoming courses, automatic weapons are sited with about 300 to 400 yards between adjacent fire units. In no event should adjacent fire units be sited more than 750 yards from each other. The minimum distance between fire units is 150 yards.

b. The fire units are placed as close to the edge of the objective as is practicable and are kept within the lateral distances mentioned above. If sufficient fire units are available, the defense is spread outward along probable avenues of approach.

c. In the event that terrain difficulties prevent placing the fire units in the proper positions, these weak points in the defense must be strengthened by siting additional weapons.

20. COORDINATION OF DEAD AREAS. a. Since in director-controlled fire, each fire unit has a dead area of 70° for low angle fire, it is necessary to provide coverage for this area. This coverage is accomplished by siting adjacent fire units so that the dead area of one unit is covered by the fire of the other. In coordinating the dead areas, the following factors are considered:

(1) Each gun must be able to cover its assigned sector of fire.

(2) The dead area of each 40-mm gun must be covered by the gun of an adjacent fire unit.

(3) The defense must be such that a reasonable number of the weapons can place fire over the objective.

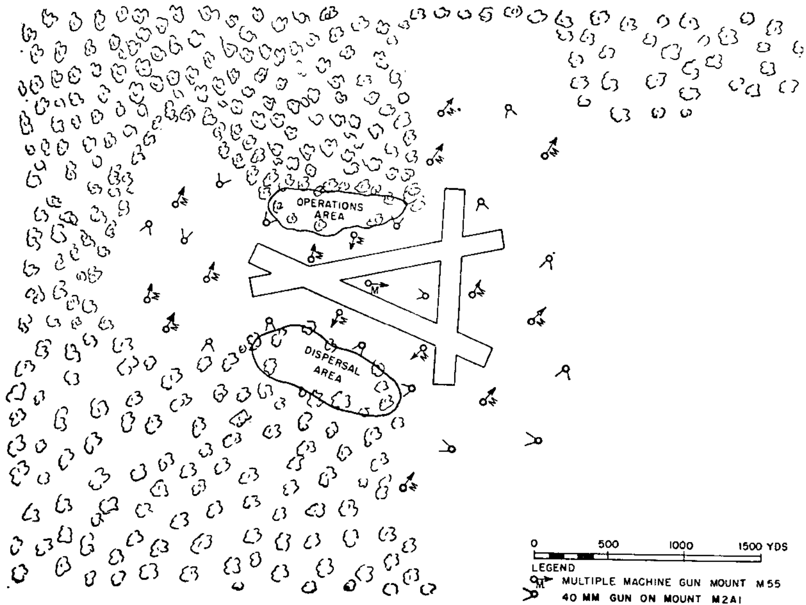

Figure 22. Defense of an objective showing coordination of dead areas.

(4) If the objective offers considerable mask to closely sited weapons, place the dead areas toward the mask. If the objective offers no mask, one side of the dead area will be tangent to the outline of the objective or toward another mask.

b. Use of the above rules for coordinating dead areas of the 40-mm guns allow free use of the multiple machine-gun mounts (fig. 22).

CHAPTER 2

EMPLOYMENT IN THE ANTIAIRCRAFT MISSION

Section I. EMPLOYMENT OF ANTIAIRCRAFT ARTILLERY AUTOMATIC WEAPONS

21. GENERAL. a. Automatic weapons units in rear areas usually consist of corps, army, or communication zone troops. Since the objectives they are to defend are of a permanent or semi-permanent nature, the problem of mobility is not a serious one. Either towed or self-propelled weapons are available for such missions. Typical of these missions is the protection of airdromes, ports, supply installations, railroads, bridges, or other installations vital to combat troops.

b. Automatic weapons operating with ground combat troops in a moving situation provide protection for troops and nonpermanent installations which are likely to become targets for an air attack. The automatic weapons must be mobile because the elements which they are defending change positions frequently. The self-propelled weapons which are organic with divisional troops are well suited to this type of employment.

c. Since there is seldom enough antiaircraft artillery available to defend all possible targets,

it is necessary to determine which will receive protection. A priority list is established for each tactical situation; this list is based on the vulnerability of an element, its organic antiaircraft weapons, and its importance to the accomplishment of the mission. Using these factors, the antiaircraft commander makes his recommendations for antiaircraft artillery defense and forwards these recommendations to the commander concerned.

22. BASIS FOR EMPLOYMENT. a. Automatic weapons in rear areas are usually a part of a coordinated defense and are tied in with the AAOC and the AAAIS. Divisional automatic weapons battalions normally are not a part of the coordinated antiaircraft defenses of a larger unit but are, whenever practicable, tied into the AAA's net for intelligence.

b. The defense of airdromes and airstrips is of great importance. Friendly aircraft must have protection against enemy planes during take-off, first few minutes of flight, and landing. Without such protection they cannot maintain local air superiority. A typical airdrome is shown in figure 20.

c. Railheads, ports, and important bridges are defended as long as they have military value. Supply installations and troops may not require antiaircraft artillery protection if they are sufficiently dispersed and concealed.

d. The antiaircraft artillery defense of any objective is planned in accordance with the principles laid down in paragraphs 16 through 20.

e. Ground combat forces are protected while on the march by the self-propelled weapons that move in the column with them.

f. An antiaircraft artillery automatic weapons unit may be employed under centralized control and *in support* of the defended unit. It also may be employed in a decentralized manner with various elements of the automatic weapons unit *attached for operational control* to the defended unit. This attachment normally will include responsibility for supply and services.

g. Automatic weapons may or may not be disposed as a unit when operating with ground combat forces. When operating as a unit or when they are close enough for effective centralized control, the automatic weapons are in support of the defended units. If the elements of the automatic weapons battalion are too far removed for effective centralized control, it is desirable to attach these elements to the defended units for operational control. The determination of when to put the automatic weapons in support and when to attach them for operational control is a command decision.

h. Care must be taken to conceal the disposition, emplacement, and shifting of automatic weapons operating with ground combat units so as not to divulge vital information to the enemy. If the

situation permits, the fire units move at night and are in position and ready to fire before daylight.

23. EMPLOYMENT WITH ARMORED UNITS. a. General. The basic principles of employment of antiaircraft artillery automatic weapons with armored forces are the same as those employed with any other type ground combat unit in a moving situation. It is essential for the automatic weapons to be of the self-propelled type if the defense is to be continuous and effective.

b. Priorities. In recommending priorities for antiaircraft artillery protection, the appropriate commander considers the automatic weapons available and the installations most vulnerable to air attack.

c. Control. Armored units normally are employed to take full advantage of their mobility and fire power. Automatic weapons protecting these units become widely scattered. In such situations control may become decentralized to the extent of attaching for operational control an automatic weapons battery or part of a battery to an armored unit.

24. EMPLOYMENT WITH FIELD ARTILLERY. A frequent mission of antiaircraft artillery automatic weapons is to provide antiaircraft artillery protection for the field artillery. The normal employment is one antiaircraft artillery battery per field artillery battalion; however, if a number of field artillery battalions are in a relatively small area, an automatic weapons battalion may be given the

mission of protecting the entire area. For a more complete discussion of the employment of antiaircraft artillery automatic weapons with the field artillery, see paragraphs 30 through 40.

25. PROTECTION OF CONCENTRATION AND BIVOUACS. Concentrations and bivouacs are likely targets for air attack. Troop movements into and from concentration areas should be unimpeded and unobserved, and troops within the area should be protected from air attack and aerial observation. Automatic weapons either move with the troops or arrive in the area ahead of them. Camouflage discipline and passive defense measures are an important part of the defense.

26. TROOP MOVEMENTS. Ground combat troops are extremely vulnerable while on the march. Such movements may be protected by defending critical areas along the route of march or protection may be provided by having self-propelled antiaircraft weapons in the line of march. Having weapons in the line of march is the best solution for defense of a column; the self-propelled weapons can offer continuous and effective defense at any spot along the route of march.

27. THE OFFENSIVE. The problem of furnishing protection in support of an offensive usually is one of warding off enemy air attacks designed to stall the offensive, and of denying the enemy observation of friendly operations, particularly during the preparation and development of the attack.

28. THE DEFENSIVE. When a force is on the defensive, automatic weapons protection becomes of increasing importance because the enemy most likely will have local air superiority. A hostile attack probably will be supported by a heavy air attack. Under such circumstances, the antiaircraft artillery provides most of the defense against air attack and will be supplemented by the organic antiaircraft weapons of the defended unit.

29. RETROGRADE MOVEMENTS. Retrograde movements may be made either at night or during the daylight hours. In daylight movements antiaircraft artillery protection is especially important. Priority for this protection includes those units and installations that are vital to the success of the movement.

Section II. EMPLOYMENT OF ANTIAIRCRAFT ARTILLERY AUTOMATIC WEAPONS BATTALION (SP) ORGANIC TO THE INFANTRY DIVISION

30. MISSION. The antiaircraft artillery automatic weapons self-propelled battalion that is organic to the division is charged with the antiaircraft defense of the division.

31. CONTROL. The antiaircraft artillery battalion operating with the infantry division has parts of the battalion with various divisional troops. The division tables of organization and equipment place the self-propelled automatic weapons battalion in the division artillery and under the com-

mand of the division artillery commander. In many cases the automatic weapons batteries or platoons are too widely separated for the battalion commander to have effective control. In these situations it is more desirable for the automatic weapons to be *attached for operational control* to the units they are defending. Under conditions where the automatic weapons battalion commander can effectively administer his organization, centralized control is advisable.

32. PRIORITIES. It is the responsibility of the division artillery commander to recommend the proper disposition of the antiaircraft weapons. An important step in this disposition is the determination of priorities. These priorities are determined by the division commander based on the recommendations of the division artillery commander.

33. TYPE MISSIONS. Self-propelled automatic weapons may be employed effectively on the following type antiaircraft missions (this list is not necessarily in order of priority):

a. Protection of foot and motor marches.

b. Protection of organic and attached field artillery.

c. Defense of assembly areas.

d. Protection of supply trains, command posts, and other important divisional installations.

e. Protection of engineers and engineer equipment while constructing bridges or defense of bridges after completion.

f. Defense of critical areas or defiles.

g. Support of infantry on the defensive.

h. Defense of main battle position or vital installations on the defense.

i. Protection of division reserve.

34. EMPLOYMENT ON THE MARCH. a. When ground combat troops are on the march, they may be attacked from the air at any point on the route. To provide adequate protection, it is necessary that the antiaircraft artillery defense be continuous. This continuous protection is accomplished by having the self-propelled automatic weapons disposed throughout the column within mutually supporting distance of each other. If the tactics of the enemy stress hitting a particular section of a column, then that section will have the heaviest distribution of antiaircraft artillery weapons.

b. The organic automatic weapons battalion may be required to defend critical points along the route until the mission is assumed by corps or army antiaircraft artillery. However, it is desirable that these critical points be protected by corps or higher headquarters antiaircraft artillery troops. This permits the organic antiaircraft artillery to stay with its unit during the march.

c. The number of columns and the length of individual columns preclude centralized control. The control usually is given to the commander of the unit to which the automatic weapons are attached.

d. In rail movements, antiaircraft artillery protection is provided by mounting automatic weap-

ons on flat cars or gondolas and spotting them throughout the train within mutually supporting distance of each other.

35. EMPLOYMENT WITH FIELD ARTILLERY. a. General. When automatic weapons units are used to defend field artillery, the normal allotment of antiaircraft artillery weapons is one automatic weapons battery per field artillery battalion. When the entire field artillery battalion is together, the automatic weapons battery organization is satisfactory. However, the field artillery may move in bounds with one firing battery moving at a time. Since continuous protection is desired, it may be necessary to divide the automatic weapons battery into three provisional platoons of 6, 6, and 4 fire units, and give each platoon thus formed the mission of protecting a specific field artillery battery.

b. Disposition.

(1) The basic principles of antiaircraft artillery defense remain the same. There are, however, certain factors that pertain to the defense of a field artillery unit. Automatic weapons should not be located closer than 100 yards to the nearest field artillery piece. Since an air attack is most likely to be made along the line of guns, the best sites for the antiaircraft artillery weapons is on the flanks. If automatic weapons are to be placed to the rear of the field artillery guns, the effect of hostile counterbattery fire must be considered.

(2) The organic antiaircraft caliber .50 machine guns of the field artillery should be considered in planning a coordinated defense under the antiaircraft artillery commander. When possible, the antiaircraft artillery defense must be coordinated with adjacent units.

c. Liaison.

(1) Close liaison is maintained with the defended unit at all times.

(2) Information for reconnaissance and movement normally come from the field artillery commander.

(3) Warning of hostile ground attack normally comes from the field artillery commander.

36. PROTECTION OF BIVOUACS AND CONCENTRATIONS. **a.** When the antiaircraft artillery is defending bivouacs and concentrations, emphasis is placed on passive defense. Premature firing or ineffective firing will indicate that there is an important objective in the area. Firing thus will betray the secrecy desired and possibly bring an attack on the area. Passive defense must be stressed and fire should not be brought on enemy planes unless they attack or unless there is a good chance of destroying the target. Rules for opening fire in such situations is a command decision.

b. Priorities for defense in a concentration area will include critical points along the routes to and from the area, detraining and entraining areas,

installations, and troops. The basic antiaircraft defense should be supplied by the highest echelon possible so that the organic antiaircraft troops may move with their units without unduly disturbing the defense.

c. Usually automatic weapons will be the only antiaircraft provided for the defense of a bivouac area. In determining their disposition, consideration must be given to the amount of organic antiaircraft automatic weapons available in the defended units, and the extent passive defense measures can be utilized.

d. Providing an effective defense requires that the antiaircraft artillery in the defense be coordinated and under centralized control. The senior antiaircraft artillery officer present is normally responsible for this coordination and control; if a battalion group is formed, the commander of the battalion organic to the division is responsible.

37. THE OFFENSIVE. ***a.*** Priority for automatic weapons defense is given those elements and installations whose protection is most vital to the accomplishment of the mission. These priorities may include artillery areas, critical points, reserves, assembly areas, supply installations, and concentrations of troops involved in the main effort. The priorities are established as indicated in paragraph 21**c**.

b. The antiaircraft artillery is supplemented by the organic antiaircraft weapons of the division units. Whenever possible, these weapons are co-

ordinated with the weapons of the organic antiaircraft artillery.

c. Since automatic weapons will be employed well forward in an offensive, often within range of hostile artillery, positions selected should offer defilade as well as concealment from enemy observation.

d. In the attack of a river line, the automatic weapons defense is centered around the crossing fronts, particularly the sites of bridges. This requires the antiaircraft artillery automatic weapons to be among the first units to arrive at the crossing sites. If the situation permits, part of the automatic weapons will cross the river and occupy positions on that side. Protection must be afforded personnel constructing the bridges and the bridges must have continuous protection after they are completed.

38. PURSUIT. A pursuit is essentially an offensive action that is moving at a rapid rate. It involves either direct pressure or an encircling action. The same principles of antiaircraft artillery defense in an offensive action apply for this type mission; the chief difference is the speed of movement and the necessity of decentralizing control. The control problem is solved by attaching the automatic weapons units to the units they are defending.

39. DEFENSIVE. **a.** The strong possibility that the enemy will have local air superiority makes the period of organizing and occupying defensive positions a critical one. The automatic weapons are

disposed initially to protect the organization and occupation of the main battle position from hostile observation and air attack. After the position is organized, other elements of the defense take over priority for automatic weapons. Those high priority elements include troops defending the most vital areas of the battle position, the artillery, and the reserves in a counterattack. If sufficient antiaircraft artillery is available, some of the automatic weapons units will be given the defense of important supply installations and critical defiles along the routes to the defensive position. The AAAIS gives prompt warning of the approach of hostile aircraft to all units concerned.

b. In planning a defense, maximum stress must be placed on passive defense measures. The defense must be coordinated with adjacent units and tied into the AAAIS. Organic antiaircraft weapons of the defending units should be coordinated with the weapons of the antiaircraft artillery and utilized to the maximum extent.

c. Employment of antiaircraft artillery weapons in a counterattack is similar to their employment in the offensive. The planning will include the prompt re-establishment of the defense when the objective of the counterattack is secured.

d. In the defense of a river line, the automatic weapons are employed to protect the artillery and the reserves. In addition, some automatic weapons are provided on or near the river line.

40. RETROGRADE MOVEMENTS. a. General. Retrograde movements usually are made under cover

of darkness to preserve secrecy. However, the tactical situation may demand a daylight move. In this event the importance of antiaircraft artillery protection is greatly increased.

b. Priorities. As in all cases, the tactical situation will determine the priorities. A chief consideration is the protection of elements moving to the rear and critical points along the route since it is essential that the leading elements not be stopped and the withdrawal route blocked. Another important consideration is the rear guard and artillery remaining in position to cover the withdrawal. The commander concerned will establish these priorities.

Section III. EMPLOYMENT OF ANTIAIRCRAFT ARTILLERY AUTOMATIC WEAPONS BATTALION (SP) ORGANIC TO THE ARMORED DIVISION

41. MISSION. As in the infantry division, the armored division has an organic self-propelled automatic weapons battalion. This battalion is charged with the antiaircraft artillery defense of the division. When the situation indicates the need for additional antiaircraft artillery protection, it is essential that the antiaircraft artillery attached be self-propelled.

42. CONTROL. Under the division tables of organization and equipment the antiaircraft artillery automatic weapons are a part of division artillery. As such they come under the command of the division artillery commander. The combat com-

mands of an armored division operating on a normal mission become widely separated. Often these combat commands are further broken down into task forces which operate as tactical units. Automatic weapons units operating with the combat commands or special task forces are often too far removed from their parent unit for centralized control. Under such conditions, it is desirable to attach for operational control the automatic weapons units to the unit they are defending. When the situation again becomes so stabilized that the battalion commander can effectively control his unit, control then becomes centralized.

43. PRIORITIES. It is the responsibility of the division artillery commander to prepare a priority list of elements to be defended by the automatic weapons and to forward this list in the form of a recommendation to the division commander.

44. TYPE MISSIONS. The self-propelled automatic weapons battalion may be employed effectively on the following type antiaircraft missions:

a. Protection of march columns.

b. Protection of organic and attached field artillery.

c. Defense of assembly areas.

d. Protection of supply trains, command posts, and other important divisional installations.

e. Protection of engineers and engineer equipment while constructing bridges or defense of bridges after completion.

f. Defense of critical areas or defiles.

g. Support armored infantry.

45. EMPLOYMENT ON THE MARCH. a. General. Protecting an armored column on the march follows the same general principles as protection of infantry on the march. However, the great mobility of the armored division makes the use of self-propelled weapons mandatory.

b. Priorities. The antiaircraft weapons are distributed throughout the column in accordance with the priority list recommended by the division artillery commander and approved by the division commander. The priorities will be somewhat different from those of an infantry division. The tanks are not only less vulnerable to air attack than other elements, but also are equipped with organic antiaircraft weapons. The armored field artillery has one caliber .50 machine gun per armored weapons and, in addition, has armor plate protection. The armored infantry ride in tracked vehicles with little armor protection; these vehicles mount one caliber .50 machine gun each. The supply trains are probably the most vulnerable element to air attack.

c. Conduct of march. Weather conditions or terrain may dictate that the armored column remain on the road. This condition increases the importance of antiaircraft artillery protection because a road-bound column makes an easy target if leading elements are attacked and the road becomes blocked. A column on foot almost always can leave the road and disperse, but a road-bound

armored column is an easy victim if adequate protection is not available. At any time the column is stopped, each automatic weapon must be located where it can fire effectively at enemy planes; this may be in the normal column position, or it may require movement to the flank. *Antiaircraft artillery protection must be continuous.*

d. Liaison. The rapid movement of armored columns and the frequent unplanned changes in direction of movement make close liaison between the antiaircraft artillery and the defended unit a very vital necessity. Antiaircraft artillery weapons that become separated or lost are of no value to the armored units.

46. EMPLOYMENT WITH ARMORED FIELD ARTILLERY.

a. Quite often the armored field artillery is high enough on the priority list to warrant antiaircraft artillery protection. The normal allotment for armored field artillery is the same as for the towed field artillery—that is, one automatic weapons battery per field artillery battalion.

b. When the field artillery battalion displaces by echelon or in event one field artillery battery is operating as a part of a small task force separate from the field artillery battalion, it is necessary to form provisional AW platoons to provide AAA protection, as described in paragraph 35**a**.

c. In emplacing the automatic weapons the principles described in paragraph 35**b** apply.

d. Since the armored field artillery has many organic antiaircraft weapons they should be coordinated, whenever possible, with the antiaircraft

artillery automatic weapons of the defending unit.

e. The tactical situation sometimes makes it necessary to attach towed field artillery to an armored division. Such a unit is extremely vulnerable when on an armored division mission. If the towed artillery does not have its antiaircraft artillery protection, it should be higher on the priority list for the division antiaircraft artillery automatic weapons than the organic armored field artillery.

f. The liaison problem is the same as for an infantry division.

47. PROTECTION OF BIVOUACS AND CONCENTRATIONS. The defense of bivouacs and concentrations entails the same problems as those of an infantry division (par. 36).

48. THE OFFENSIVE. **a.** A major portion of an armored division offensive is the road march to the objective. The protection of this phase of the offensive follows the principles laid down in paragraph 37.

b. An important characteristic of the self-propelled weapons is that they can accompany an armored division in an attack. To provide continuous protection for an element, the automatic weapons unit must be able to stay with that element.

c. For each offensive action, priorities are established. The following vital elements of the division warrant protection when on the offensive (these elements are not listed in order of priority) :

(1) Supply trains.
(2) Field artillery.
(3) Assembly areas.
(4) Engineer construction.
(5) Critical points on the route of communication.
(6) Motor columns.
(7) Infantry.

49. DEFENSIVE. **a.** Unless the situation demands it, an armored division is not used in the line of defensive action. By holding the armor in reserve, ready to counterattack and pinch off any enemy penetration, the maximum effect of its great fire power and mobility can be attained.

b. In planning a defense, it can be assumed that the enemy will have at least local air superiority. This air power will strike any element of the defense that will enable the offensive action to proceed with more ease. Since the armor that is held in reserve is concentrated, it is a likely target and worthy of antiaircraft protection.

c. The antiaircraft artillery defense of the division assembly or concentration area is greatly aided by passive defense measures.

d. Critical points such as bridges and defiles along the possible routes of counterattack must be defended.

e. The armored artillery will not be in reserve and very likely will need antiaircraft protection.

f. The disposition of individual weapons is in accordance with the principles discussed in paragraphs 16 through 20.

50. RETROGRADE MOVEMENTS. a. When part of a larger force, the armored division aids in a withdrawal by attacking the enemy forces exerting the greatest pressure. The antiaircraft artillery defense for such an operation is discussed in the paragraph on offensive action.

b. When operating alone, the armored division follows the basic principles of withdrawal. The antiaircraft artillery defense on these operations is discussed in paragraph 40.

CHAPTER 3

EMPLOYMENT IN THE SURFACE MISSION

Section I. CLOSE SUPPORT OF INFANTRY—GENERAL

51. GENERAL. **a.** Under the present tables of organization and equipment, the infantry division has one organic antiaircraft automatic weapons battalion assigned to it. This battalion is assigned the mission, either antiaircraft or surface, dictated by consideration of the greatest threat to the over-all mission of the force.

b. When the automatic weapons are diverted to the close support role, the desirable allocation is one battery attached for operational control to each of the two attacking infantry regiments. Under the conditions of this attachment, each of the two infantry battalions in the line can have a platoon of antiaircraft automatic weapons attached. The remaining automatic weapons batteries may be used in either the antiaircraft or surface mission in accordance with the priorities established by the division commander.

52. TACTICAL EMPLOYMENT. The organic antiaircraft automatic weapons battalion with the infantry division is the self-propelled battalion. This

type of battalion is best suited for the mission of ground support because of its mobility.

a. Mobility.

(1) The self-propelled weapon is able to move very rapidly over most types of terrain. It can displace quickly and be ready to fire from new positions in a short time. In the event of hostile counter-fire, it loses no time in moving to alternate positions.

(2) The towed 40-mm gun is less suitable for a ground support role. It is limited in its mobility by the prime mover and the length of time needed to properly emplace it. Rapid displacement cannot be effected, thereby making continuous support of the infantry difficult.

b. Capabilities and limitations of automatic weapons.

(1) All antiaircraft automatic weapons are well suited for furnishing heavy fire support to the infantry in either the offense or the defense. Their great fire power can be of much assistance in augmenting the fires of the infantry heavy weapons. They can be used effectively to knock out machine-gun emplacements, positions in caves and buildings, and similar obstacles to the attack by friendly infantry. They are especially effective against personnel and unarmored vehicles.

(2) Present type automatic weapons have very light armor and offer little protection to the crew. The trajectory of these weapons is so flat that very little defilade can be used. These two characteristics combined make the selection of a position difficult and offer a definite limitation. In spite of the high muzzle velocity, the weapons cannot be used as antitank guns except against very lightly armored vehicles; their best employment in this role is to supplement heavier guns by forcing armored vehicles to keep "buttoned-up" and to attack personnel accompanying the armored vehicles. The supersensitive fuze used on 40-mm high explosive ammunition makes it unsafe to fire over friendly troops in wooded areas. The M16 is limited in its fire at low elevations over the front of the vehicle.

53. COMMAND AND CONTROL. The antiaircraft battalion commander is an advisor to the division artillery commander on antiaircraft artillery matters. He is charged with keeping the division artillery commander informed on the capabilities of his unit and making recommendations as to its employment. The infantry regimental and battalion commanders exercise command functions over the antiaircraft units attached to their organizations and have, as special staff officers, the automatic weapons battery and platoon commanders, respectively. The antiaircraft artillery bat-

tery command post is at or near the infantry regimental command post, and the antiaircraft artillery platoon command post is at or near the infantry battalion command post. The normal role for the platoon commander is to direct the fire of his platoon while the platoon executive remains in liaison with the battalion commander. Fire direction is accomplished with each automatic weapon as a separate unit and under the direct supervision of the platoon commander.

54. COORDINATION AND LIAISON. a. The proximity afforded by adjacent command posts enables the antiaircraft artillery commanders to establish and maintain close liaison with the infantry.

b. The platoon executive normally establishes liaison with the infantry battalion commander and remains with him during operations. Each infantry company in the line has an antiaircraft artillery noncommissioned officer to act as a forward observer. This noncommissioned officer stays close to the infantry company commander and brings fire upon targets as requested. He has at least one other man with him to act as radio bearer and operator.

c. Each squad leader shifts and directs the fire of his automatic weapons as ordered by the platoon commander. He engages targets of opportunity in his assigned sector of fire on his own initiative.

d. Good communications are a vital part of any close support mission. It is essential that the com-

munication system established provide rapid and efficient communication between the automatic weapons commander and the infantry battalion commander, and between the automatic weapons commander and the fire unit commander. Normally communication is by radio with the SCR 300's provided for that purpose. In certain slow-moving situations wire communication may be used. The self-propelled automatic weapons battalion has both radio and wire communications as organic equipment.

e. Fire orders must be as brief and concise as possible and follow the form laid down in the manuals for the service of the piece of the weapons involved. Training in this is vitally important because the success of a mission often depends on the speed in bringing fire on a target.

f. The designation of targets is aided by the use of range cards at each weapon and by the fire control officer. The range cards show the prominent terrain features and likely targets, with the approximate ranges and quadrant elevations for each target. A satisfactory substitute for the range card is a map with a thrust line drawn on it.

g. When supporting an offensive action, automatic weapons must have a *predesignated safety line* to limit their action for the safety of friendly troops. This line probably will be identified by a terrain feature or some prominent mark that is easy to distinguish. The antiaircraft artillery personnel with the attacking infantry must know the location of this line and inform the fire control officer when the troops near the line (FM 7–20).

55. FIRE PLAN. The antiaircraft artillery commander submits his plan for the support to the infantry for approval. This plan should include the following information:

a. Plan of supporting fires.

b. General position areas.

c. Targets and sectors of fire.

d. Condition or time of opening and lifting fire.

e. Conditions or time for displacement.

56. SECURITY. Local security is the responsibility of the unit commander concerned. When moving into position or along the road, full advantage must be taken of cover and concealment. Positions selected should, whenever possible, be in an area where some protection is offered by adjacent troops. Each fire unit provides its own security and is especially watchful for infiltration by enemy personnel. A warning system must be established and any information of enemy movements must be forwarded to the next higher headquarters immediately on receipt.

57. REFERENCES. References for further study of this subject matter may be found in appendix I.

Section II. CLOSE SUPPORT OF INFANTRY—DEFENSIVE COMBAT

58. GENERAL. This section is concerned with the employment of antiaircraft artillery automatic

weapons in a close support role in defensive combat with the infantry.

59. RECONNAISSANCE. **a.** The reconnaissance by the automatic weapons unit commander is as detailed as time permits. The care with which positions are selected, and the vital importance of routes of movement into and concealment of positions generally render selection of positions from map study alone inadequate and dangerous. In the hasty assumption of the defensive, it may be necessary to occupy temporary positions to assist the defense and conduct detailed reconnaissance later as time permits.

b. In the assumption of the defense, out of contact with the enemy, the antiaircraft artillery automatic weapons unit commander ordinarily accompanies the infantry commander and his staff on reconnaissance. He may be detailed by the infantry commander to reconnoiter designated areas and make specific recommendations as to the employment of his weapons.

c. Based on the instructions of the infantry commander, the automatic weapons commander first must identify the area his unit is to occupy and select covered approaches into that area. He then plans his reconnaissance and the route he is to take. The reconnaissance should determine the following:

(1) The likely avenues of approach for hostile forces.

(2) Possible position areas for automatic weapons units in support of security forces.

(3) Probable position areas for enemy direct fire weapons and observation posts so that these areas may be neutralized with long range fires.

(4) Key points within the battalion area that are essential to the defense of the area.

(5) Exact location of primary and alternate positions for all weapons of the unit.

(6) Location of positions suitable to support a counterattack.

(7) Location of positions to support extension of the MLR to meet an envelopment.

(8) Location of platoon or battery observation posts.

(9) Location of ammunition supply points and routes of ammunition supply.

60. RECOMMENDATIONS AND PLANS. a. Based on the ground reconnaissance, the automatic weapons unit commander submits recommendations to the infantry commander for the use of the automatic weapons. These recommendations include the selected position areas, the missions which can be accomplished from these areas, and the routes of movement into these position areas.

b. Plans for the employment of automatic weapons must be coordinated with those of the infantry. They include security, distribution, location, and

missions of all weapons of the antiaircraft artillery unit, and provide for the coordination of their fires with the fires of infantry weapons.

c. If the defense is assumed when in contact with the enemy, and the situation does not permit thorough planning, temporary positions are occupied to assist the defense and plans are developed as time permits.

61. SELECTION OF POSITIONS. a. Positions for antiaircraft artillery automatic weapons in ground support of defensive action are selected with the following factors in mind:

(1) To assist in the protection of vital terrain features.

(2) To retain essential observation to front and flanks.

(3) To deny the enemy close observation into the battle position.

(4) To provide good fields of fire for weapons located in the rear portions of the battalion area.

(5) To take maximum advantage of natural cover and concealment.

(6) To be out of enemy small arms range.

(7) If possible, the caliber .50 machine gun should be within 1,000 yards of target and the 40-mm gun within 1,500 yards of target.

(8) To coordinate with the infantry on the battle position so that each provides mutual protection for the other.

b. The automatic weapons usually are disposed in the rear portion of the battalion area. Positions selected provide maximum defilade for the weapon and its crew consistent with the mission assigned. All emplacements must be concealed carefully. Fire is withheld until appropriate targets develop or the infantry commander directs fire to be delivered. All personnel must be familiar with the location of alternate positions and be able to move into them rapidly.

62. PREPARATION OF POSITIONS. **a.** When time permits, emplacements are dug and camouflaged before the weapons move in. These emplacements are constructed to afford the maximum protection to the crew, consistent with the mission. A ramp leads into each position to facilitate a rapid displacement if necessary. Each pit is provided with an ammunition storage shelter. The same care in preparation is given alternate positions when time permits. All positions are continually improved as long as they are occupied.

b. In some types of terrain, fields of fire may have to be prepared. If this is necessary, care must be taken not to make lanes pointing definitely to the position.

c. The positions are camouflaged with care, using the principles outlined in chapter 6. Camouflage in itself is worthless unless camouflage discipline is enforced; there must be no unnecessary movement around the position area.

d. Since the time available is an important factor, there is set up a priority list for preparation

of a position. Many of the following tasks may be carried on concurrently:

(1) Weapons placed in temporary positions.

(2) Preparation of primary positions.

(3) Clearing fields of fire.

(4) Establishment of communications.

(5) Preparation of individual shelters.

(6) Preparation of alternate positions.

e. If time permits the construction of dummy positions, they will do much to confuse the enemy and disperse his fire. The more realistic these dummy positions are, the more effective they will be.

f. Each member of the gun crew must dig a foxhole for protection against artillery, mortars, and machine-gun fire. These shelters should have heavy overhead cover to protect against time fire.

63. MOVEMENT INTO POSITION. Upon completion of reconnaissance and approval of the plan of action by the infantry commander, the automatic weapons move into the prepared positions. This movement is coordinated with the infantry so that the motor columns will not interfere with the movements of the foot troops. It is desirable that the movement be made at night but, in many cases, it is necessary to make a daylight movement. Utmost use of concealed or covered approaches is made. Since the self-propelled units make so much noise, it may be necessary to move into position under the cover of an artillery preparation or to

wait until just before the attack. If surprise is to be a feature of the action, the noise-making of the self-propelled weapons must be considered.

64. DISTRIBUTION AND MISSIONS. Part of the automatic weapons are given such missions as interdiction, harassing, and neuturalization types of fire. The remainder of the weapons augment the infantry heavy weapons in furnishing close support by overhead fire and fire through gaps in the friendly lines. These close support weapons aid in limiting enemy penetration, fire within portions of the defended area that have been penetrated by the enemy, and support friendly counterattacks.

65. THE FIRE PLAN. **a.** All automatic weapons support fires must be carefully prepared, planned, and coordinated with the infantry units. The infantry mission in defense is to stop the enemy by fire in front of the battle position, to repel his assault if he succeeds in reaching the position, and to eject him by counterattack if he succeeds in entering the position. Therefore, any fire which can be placed by machine guns or cannon on small targets, such as enemy machine guns, groups of hostile personnel, observation posts, and light vehicles, aids the infantry mission. Likewise, fire which limits or neutralizes enemy observation over a period of time assists in halting an enemy attack. This is done by firing on areas likely to be used by the enemy for observation, or position areas for hostile direct fire weapons. Interdiction fires on roads and trails are accomplished by en-

gaging them at periodic intervals or by laying the weapon on the area and engaging enemy targets as they appear. Planned harassing fires are registered either deliberately or during the course of the battle. Fires within the position, fire to the flanks, or into enemy penetrations must be planned and coordinated with the infantry commander and delivered as requested. The automatic weapons must be coordinated with the infantry heavy weapons and they all must be mutually supporting.

b. Antiaircraft artillery automatic weapons will be incorporated in the counterattack plans of the infantry. When it is possible, the infantry counterattack is delivered against the shoulder of the enemy penetration. Fire in support of this attack is delivered from previously selected and prepared positions into the penetration and along its flanks. Other automatic weapon fires are placed on enemy supporting weapons and observation. The high rate of accurate fire of antiaircraft artillery automatic weapons makes them suitable for this task.

c. When the situation permits, self-propelled weapons are used with combat outposts. Positions to be occupied should, if possible, offer good cover and concealment. Good observation is not only desirable but necessary. Fires delivered in support of outposts are usually fires from 1,000 to 2,500 yards; their purpose is to delay the enemy advance and deceive him as to the real location of the principal battle position. Cooperation with the infantry elements is essential to proper support. The route of withdrawal is of primary importance and is well planned.

66. RATES OF FIRE. The rates of fire of automatic weapons in close support are governed by tactical and supply considerations. The following rates are guides; actual rates to be used depend upon local conditions.

a. Harassing fires may be accomplished by any type automatic weapon. If the multiple machine-gun mount is used, only two guns should be fired at a time; as these two guns become hot, they are alternated with the remaining two guns of the mount. The machine guns are fired in short bursts at a rate of about 100 rounds per gun per minute. If the 40-mm gun is used, it is fired at a slow rate (about 15 rounds per minute).

b. Interdiction fires with the machine guns are fired in bursts of about 20 rounds per gun at irregular intervals, or against targets as they appear. 40-mm interdiction fires are in five-round bursts.

c. Neutralization fires are delivered at higher rates. If the multiple mount machine guns are used, they are fired in pairs and at the maximum rates for periods of 2 to 3 minutes. 40-mm fire is at the rate of about 60 rounds per minute. The type targets to be neutralized are definitely known concentrations of enemy personnel or located enemy weapons.

d. Protective fires with machine guns are delivered at a rate of about 200 rounds per gun per minute. The guns are alternated so that continuous fire is available for periods of about 10 minutes at a time. 40-mm gun fire is usually at the

rate of about 30 rounds per gun per minute. This type of fire is placed on fixed lines across the front of organized defensive areas adjacent to the gun positions.

67. NIGHT DISPOSITIONS OF THE DEFENSE. **a.** The defense must be prepared to repel a hostile attack or prevent small groups from infiltrating into positions at night or under other conditions of reduced visibility. At night weapons may be moved to protected positions where they can cover predetermined lanes of fire. Those weapons which have disclosed their positions by firing during daylight are particularly susceptible to raids by small infiltration parties. Weapons which are to be used for night firing should be moved to temporary positions which will not reveal their primary positions.

b. Defense at night depends upon prearranged fires, fires with artificial illumination, and hand-to-hand combat. Early information of hostile movement is essential. Listening posts are established to cover trails and other avenues of approach into the defense area.

68. CONDUCT OF THE DEFENSE. **a.** The integrity of the defense area is maintained by a combination of fire and counterattack. Fires must be delivered in accordance with the infantry fire plan or laid down on call from the infantry commander. Fire plans are prepared for all gun positions for all possible types of fire.

b. Antiaircraft automatic weapons officers and forward observers should—

(1) Know the locations and fields of fire of each weapon position.

(2) Be able to advise the infantry commander of the amount and type of fire that can be delivered on any designated target.

(3) Be able to place the fire on the designated target in the amount and of the type desired.

(4) Bring the fire to bear with a minimum of delay and a maximum of effect.

c. The success of the defense depends on each element holding its assigned area. Every element is assigned the defense of a tactical locality and must defend its position to the last man unless ordered otherwise by higher authority. Troops may be required to fight in any direction. The holding of positions forms the basis for successful counterattack.

69. OPERATIONS WITH THE RESERVE BATTALION. a. Units attached for operational control to the reserve battalion function directly under the control of the reserve battalion commander. They may be employed to support covering forces or to support counterattacks. Positions for supporting counterattacks are planned and prepared in advance. Another possible use of this unit is the defense of positions protecting the flanks or the rear of the regiment.

b. Counterattack plans.

(1) The reserve battalion commander prepares plans for counterattack against one or more assumed enemy penetrations.

(2) Each such counterattack is planned so that it will strike a fully coordinated blow, supported by all available fire power, to eject the enemy from the position or destroy him and restore the main line of resistance (MLR).

(3) Automatic weapons may support the counterattack in one of two ways:

(*a*) By accompanying the infantry units to the line of departure and supporting the assault by fire through designated gaps or from the flanks. The difficulty of controlling fire and the exposure involved in movement may make this impractical in many cases.

(*b*) By timely occupation of previously selected and prepared positions where fire can be delivered into the head of the enemy penetration or along its flanks. Normally this type of employment is executed more easily. Its success depends primarily upon a timely decision by the commander of the counter-attacking forces. Some of the weapons also may be used to engage direct fire weapons supporting the enemy assault or to pursue the enemy by fire after he has been ejected from the penetration area.

(4) Whenever possible, counterattacks are rehearsed on the ground. The plans include provisions for placing and lifting fires of all weapons to insure effective coordination.

70. DEFENSE ON A WIDE FRONT. **a.** When the infantry battalion has such a wide frontage that mutual support between units is impractical, automatic weapons may be used to assist in covering the intervals. They would fire to the flanks from positions defilated to the front. Each defensive area must be capable of all around defense.

b. If adequate lateral routes exist, the weapons may be emplaced initially to deliver longer range fires, and later shifted to positions where they will be able to meet the main enemy threat. If such routes do not exist, the weapons are distributed in depth to cover the intervals between organized areas to the front and flanks.

71. DEFENSE IN WOODS. **a.** Defense in woods is characterized by short fields of fire and lack of observation; it provides more concealment than in normal cases. If friendly troops are in the woods ahead of the automatic weapons, 40-mm fire cannot be used because of the danger of overhead bursts in friendly territory. The machine guns can be used with limited effect. Limited observation requires thorough coordination and active security measures; it generally reduces the intervals between defended localities.

b. Since woods usually limit automatic weapons fires, a more extensive preparation of planned fires is necessary. Fire lanes have to be cleared for machine gun fire and guns are sited closer to the front to limit enemy penetrations and protect the flanks and rear of forward elements of the battalion.

c. Automatic weapons may be used to cover roads and trails or any other likely avenue of approach.

72. DEFENSE IN TOWNS. **a.** Automatic weapons are well suited to the defense of towns because the alleys, buildings, and cellars offer adequate concealment and protection to the weapons. The streets can be used as killing lanes for enemy infantry. Hostile attack in force usually will be canalized by the built-up portions of the town. Machine guns are sited to deliver protective fire across the front and sides of the town.

b. Stone or brick buildings can be converted readily into strongly fortified emplacements. Fires must be coordinated with those of the infantry units over streets, parks, or other open spaces or along the edges of the town.

c. 40-mm fire may be used to interdict streets if the enemy is successful in gaining entrance to the town. Alleys, cellars, or protected doorways offer good positions for this type of fire.

d. The basic principles of all around defense—defense in depth, flank protection, and counterattacks—apply for defense in towns the same as they do in open terrain.

73. DEFENSE OF A RIVER LINE. **a.** The defense of a river line corresponds generally to the defense of other similar terrain. If the river and surrounding terrain are not suitable for close defensive fires, the main line of resistance may be moved farther to the rear. In any case, the automatic weapons will be used to reinforce the fires of the infantry in the usual manner.

b. Some automatic weapons may be used close to the river line to fire on assault boats, rafts, or other light water-crossing craft. Other automatic weapons will be used to place fires on the far bank of the river to destroy located enemy weapons, collections of boats, enemy personnel, or to interdict trails leading to the stream.

74. RETROGRADE MOVEMENTS, GENERAL. **a.** Infantry units may be required to break contact with the enemy and withdraw during either offensive or defensive actions. Withdrawals may be conducted under the protection of an assigned covering force or may be protected solely by elements of its own force.

b. A front-line battalion executes a daylight withdrawal by echelon with the next unit to the rear supplying the protection. The automatic weapons will be with this protecting force and withdraw with them. In a night withdrawal from action, the entire unit moves out together, leaving a small covering force. Some of the automatic weapons usually will be left with this covering force to supplement its fire and aid in confusing the enemy.

c. Control of a withdrawal is achieved by the establishment of phase lines. A suitable area is designated as the assembly area where the infantry battalion may reorganize. Automatic weapons supporting the infantry follow this planned control.

75. DAYLIGHT WITHDRAWAL. a. General.

(1) The fact that a unit withdraws during daylight usually indicates that time is an important factor. Therefore, there is probably limited time to permit planning or reconnaissance.

(2) Self-propelled automatic weapons are valuable aids to the covering force and probably will be left with it. Plans for the action normally are made by personal contact between the small unit commanders.

(3) Orders for the withdrawal include—

(*a*) Composition and location of covering forces.

(*b*) Attachments of weapons to front line units.

(*c*) Time of withdrawal of each echelon.

(*d*) Zones of withdrawal for each unit.

(*e*) Location of assembly areas or initial phase lines.

(*f*) Routes of withdrawal of command installations.

b. Conduct of withdrawal. Once begun, the withdrawal of front line elements is conducted with all

possible speed to prevent the enemy from taking advantage of the situation. The automatic weapons supplement the fires of the field artillery and the infantry heavy weapons in interdicting hostile routes and laying down harassing fire.

c. Antiaircraft automatic weapons attached to the covering force have the mission of aiding in stopping, delaying, or diverting the enemy attack. This permits the troops in contact to disengage and move to the rear. The mobility and fire power of self-propelled weapons make them valuable weapons for this type of mission. The initial positions, missions, and length of time positions will be held are prescribed by the covering force commander.

76. NIGHT WITHDRAWAL. a. Front line battalion.

(1) A front line infantry battalion normally executes a night withdrawal by the simultaneous withdrawal of all elements, less the covering force. A successful night withdrawal depends upon careful coordination and secrecy. Movements from positions are executed as quietly as possible and elements that constitute the covering force continue to simulate all the normal activities of the battalion.

(2) Elements of the antiaircraft automatic weapons, left as part of the covering forces, remain in their positions and continue their normal activities under the command of the covering force commander. Not more than one-half of the

attached unit is left as a part of the covering force.

b. Reconnaissance. If practicable, all units conduct reconnaissance for routes to their new assembly areas or positions during daylight. The necessary guides are instructed and posted. Reconnaissance groups are limited in size to preserve secrecy.

c. Orders.

(1) Warning orders are issued to all commanders as soon as the decision to withdraw is known. Such orders, as well as the details to be issued later, should be transmitted in person to prevent confusion.

(2) Orders for the withdrawal include—

(*a*) Location of forward assembly areas for each unit.

(*b*) Routes and time of withdrawal for each element.

(*c*) Designation of units to remain with the covering force.

(*d*) Designation of commander of units with the covering force.

(*e*) Attachments of automatic weapons to infantry elements.

(*f*) Use of motor transport.

(*g*) Ammunition supply for covering force, for elements en route, and for rear positions.

(*h*) Signal communication measures and location of new command post.

d. Execution of withdrawal.

(1) Withdrawal is executed as directed by the infantry commander. Movement of antiaircraft artillery automatic weapons elements is timed so as not to interfere with the movements of infantry units.

(2) Vehicles normally are moved singly and without lights, following guides on foot ahead of individual vehicles. Sufficient motor transport is left with the covering forces to move their supporting weapons. As soon as possible after dark, nonessential vehicles are started rearward to be out of the way of combat elements.

(3) Antiaircraft artillery automatic weapons may be directed to fire barrages to conceal the sounds of the movement.

e. Withdrawal of covering force. The covering force is withdrawn under orders of the covering force commander in time to permit them to occupy rear positions before daylight. Units with the covering force are responsible for their own local security.

77. DELAYING ACTION, GENERAL. The purpose of a delaying action is to gain time while avoiding any decisive action. Delay may be accomplished by offensive action, by defensive action, or by a combination of these methods.

78. DELAY BY OFFENSIVE ACTION. Delay by offensive action follows the general principles of other

offensive actions except that the size of the units involved may be smaller. The delaying action generally is followed by a day or night withdrawal. Automatic weapons follow the same principles of close support as for the normal offensive action.

79. DELAYING ACTION FROM SUCCESSIVE POSITIONS. **a.** Delaying action from successive positions allows the delaying troops to withdraw before the enemy is close enough for decisive combat. In each position an attempt is made to force the enemy to slow his advance by forcing him off the road and generally disorganizing his forces.

b. The mission of antiaircraft artillery automatic weapons in a delaying action is to aid the infantry in delaying the advance of the enemy. Positions are selected that offer good fields of fire that permit long range firing and good observation. The automatic weapons supplement the fires of the infantry heavy weapons by laying heavy fire on the advance elements of the enemy and interdicting crossroads and possible observation points within range of automatic weapons.

c. The time and route of withdrawal is of utmost importance. Planning and reconnaissance are as complete as time permits. Arrangements for the resupply of ammunition must be made at each of the successive positions.

d. Location of future command posts and provisions for communication and control while en route are announced in the withdrawal order.

80. DELAYING ACTION FROM ONE DEFENSIVE POSITION. **a.** Delaying action from one position is used only when the same type action from successive positions is not possible. The purpose of this action is to delay and disorganize the enemy, thus giving friendly troops time to withdraw. To accomplish this mission, it may be necessary to engage in close combat; in such cases the defense is in greater depth and with more reserves than in a delaying action from successive positions.

b. The mission of automatic weapons in this type delaying action is to supplement the infantry heavy weapons in the same manner as for the defense. These automatic weapons are used to interdict crossroads, bridges, or other terrain features and to interrupt or harass enemy movement. Positions selected for this mission should provide cover and observation.

Section III. CLOSE SUPPORT OF INFANTRY—OFFENSIVE COMBAT

81. GENERAL. This section is concerned with the employment of antiaircraft automatic weapons units in a ground support role in offensive operations with an infantry battalion.

82. APPROACH MARCH. **a.** The approach march usually starts from a tactical column when hostile action is imminent. It involves deploying, leaving the road, and moving across country.

b. Even if the automatic weapons were able to accompany the infantry cross-country, the desira-

bility of such action is doubtful; the high silhouette and the noise of self-propelled weapons would pin-point the locations of the advancing infantry.

c. When the infantry deploys into the approach march, the most desirable employment of the automatic weapons is to have them revert to centralized control by the infantry battalion commander.

d. When under centralized control, the automatic weapons will move in rear of the main body and advance by bounds, taking advantage of terrain for protection against enemy action.

e. The great advantage of centralized control is that the infantry battalion commander has a mobile reserve with great fire power to send to any spot on his front where stubborn resistance develops.

f. There are tactical situations, such as mopping-up missions, where the infantry expects to meet little resistance and where the battalion front may be broad. In such cases there may be an advantage in attaching for operational control sections of the automatic weapons platoon to the infantry companies, with the control being exercised by each infantry company commander.

g. Regardless of the type of control, it is necessary for the automatic weapons unit commander to establish and maintain close liaison with the appropriate infantry commander.

83. ASSEMBLY AREA. a. General. The automatic weapons units in the ground support role supplement the defense of the assembly area against

mechanized attack. Their greatest value is in covering road blocks and attacking lightly armored vehicles and personnel.

b. Reconnaissance and occupation of position. If the terrain and the tactical situation permit, a ground reconnaissance of the assembly area is made; if this is not possible, the area and routes to the area are selected solely from a map study. It is obvious that the automatic weapons must be coordinated with the infantry defense of the area. The most desirable locations for the automatic weapons is on the perimeter, in positions that cover likely avenues of approach or in positions that cover road blocks or mine fields. Alternate positions are necessary and plans are made for moving into them.

c. Communications. Radio silence normally is observed in the assembly area to preserve secrecy. The length of time spent in the assembly area determines whether telephone communications will be set up. If time does not permit telephone installation, communication is carried on by messengers, either foot or motor.

84. RECONNAISSANCE AND PLANS. a. Reconnaissance. The automatic weapons platoon commander obtains from the infantry battalion commander the general plan of action and the amount of fire support desired. After being briefed thoroughly and having studied the map carefully, the automatic weapons commander makes a personal ground reconnaissance. This visual reconnaissance will enable the platoon commander to make rec-

ommendations to the infantry commander for the employment of the automatic weapons in support of the attack. The following items are essential information to be gained from the ground reconnaissance:

(1) Exact disposition of the infantry units, especially the front line companies.

(2) Location of known and probable enemy targets.

(3) Select primary and alternate firing positions for each weapon.

(4) Select and mark routes to initial positions.

(5) Location of firing positions to be used in forward displacements.

(6) Routes for forward displacement.

(7) Location of ammunition vehicle parks and their routes of supply.

b. Plan of manuever. The plan for employment of the automatic weapons unit must include the following:

(1) *Initial positions from which supporting fires are to be delivered.*

(*a*) The firing positions for the antiaircraft artillery automatic weapons should be in the same general area with the organic infantry support weapons. To enable the weapons to deliver supporting fire as long as possible without displacing, the weapons

are emplaced as far forward as is consistent with the tactical situation. To provide maximum cover, rear slopes and flanks of terrain features should be utilized; in flat and level terrain, the weapons must be dug-in and sandbagged, and slit trenches must be provided for the crew.

(*b*) The automatic weapons may be emplaced to fire over the heads of the infantry, from the flanks, or through gaps in the infantry line. If terrain permits, overhead firing positions are best as they allow for longer supporting fire as the infantry advances towards its objective; overhead fire also is safer for the infantry than firing through gaps in the line. Positions from the flanks are more vulnerable to enemy fire than are positions to the rear of the friendly infantry.

(*c*) The initial positions are close enough to the front to allow effective fire to be placed on the initial objective of the infantry. Effective support is continuous support and continuous support cannot be maintained if the supporting weapons have to displace before the first objective is reached.

(2) *Plans and routes of displacement.*

(*a*) To give continuous support, it is necessary to displace as the attack progresses from objective to objective.

To avoid leaving the attacking infantry without fire support, the automatic weapons displace by echelon, approximately one-half the weapons in each echelon.

(*b*) When the infantry takes an objective, it reorganizes for the attack on the next objective. During this period of reorganization, the infantry is very vulnerable to counterattack. It is highly desirable that the displacement of automatic weapons be such that the maximum fire support is available at the new area as rapidly as possible.

(*c*) Although protection against a counterattack is a primary consideration in forward displacement, the new positions must be so located that effective fire support can be given for the continuing attack.

(3) *Ammunition supply points and protected routes.*

(*a*) Because of the small basic load and the rapid rate of fire of automatic weapons, ammunition supply presents a great problem. Plans must be made so each of the positions will be amply supplied and reserve supplies close at hand.

(*b*) The amount of ammunition needed at the initial position is estimated and that amount dumped before the attack

starts. The ammunition trucks then return for a second load. These trucks are used so that they will, at all times, either have a full load or be going after one. Staggering the trips of the vehicles provides for a full truck always at hand.

(*c*) The routes forward for the ammunition supply vehicles are planned carefully and the driver must be very familiar with the plan. Covered routes are used as much as is possible.

85. SUPPORTING FIRES. a. Control of fire. The control of fire is retained by the platoon leader whenever possible. By centralizing fire control, the firing data is more detailed and more accurate; the fire also can be massed when desirable. When conditions prevent centralized control, the fire control is taken over by the section or squad leader.

b. Initial targets. The initial targets of close support weapons are those which are likely to stop or hinder the advance of the infantry as it moves toward its objective. The weapons most dangerous to the friendly infantry are enemy machine guns and other automatic weapons located so as to sweep the ground over which the infantry must advance. The primary mission of supporting weapons is to destroy or neutralize these weapons and to maintain neutralization as long as the safety of the advancing friendly infantry permits. Intrenched enemy infantry are an important target of second priority. Whenever fire power is

available, not only known targets but also any probable targets are placed under fire.

c. Priority and coordination. It is the responsibility of the infantry battalion commander to assign priority of targets and to coordinate the engagement of targets. This responsibility may be delegated to the heavy weapons company commander. The automatic weapons commander, after receiving the assignment of targets for his platoon, coordinates the fire of the platoon by assigning sector of fire to each weapon. If conditions, such as the number of targets, permit, two M16's and two M19's are assigned an identical sector of fire to provide continuity of fire, volume of fire, and overlapping fire. After destroying or neutralizing assigned targets, weapons commanders on their own initiative engage targets of opportunity in their sector of fire.

86. LIFT OR CEASE FIRE. a. Supporting fires become dangerous to the attacking infantry when the infantry comes within a certain distance of the objective. To provide safety for the friendly troops, a *predesignated safety line* is determined by the infantry commander prior to the attack. When the infantry reaches this line, firing over the heads of the infantry must cease. Fires may be shifted to targets at a greater range or in areas not occupied by the friendly infantry.

b. The *predesignated safety line* is identified by some terrain feature, if possible; if this is not practicable, the attacking infantry indicates when it has reached the point where overhead fire is

dangerous. The forward observer informs the automatic weapons commander by radio or a pyrotechnic signal, or both.

87. LIAISON AND COMMUNICATION. **a.** It is the responsibility of the automatic weapons platoon commander to establish and maintain liaison with the infantry battalion commander. It is desirable that the assistant platoon commander accompany the infantry battalion commander in the capacity of liaison officer; this allows the platoon commander to remain at the platoon command post where he can supervise and direct the fire of his unit.

b. To provide for the maximum utilization of fire power and to provide for the safety of the infantry, it is necessary to have forward observers with each attacking infantry company. Each forward observer team consists of an experienced noncommissioned officer and another man to serve as radio bearer and operator; the radio used is the SCR 300. The platoon leader also is provided with one SCR 300. The liaison officer can use the infantry battalion communication facilities.

88. ATTACK IN WOODS. **a.** Effective employment of automatic weapons in woods is limited by the following:

(1) Difficulty in maintaining direction, contact and control.

(2) Short and obstructed fields of fire.

(3) Scarcity of suitable routes for the movement of weapons.

(4) Lack of adequate observation.

(5) Difficulty of adjusting fire on targets without endangering friendly troops.

(6) Vulnerability of weapons to by-passed enemy ground elements.

b. At times, it may be necessary to clear openings from which fires can be delivered. At other times, the action of weapons may be restricted to the delivery of direct fire across existing clearings or along roads and trails for the engaging of targets of opportunity. The automatic weapons can be used to protect the flanks and rear of a unit from surprise attack. Reconnaissance personnel follow closely the attacking elements, selecting routes and positions in order that weapons can be displaced promptly to furnish close support when a clearing or the far edge of the woods is reached.

89. ATTACK OF TOWNS. Close support of infantry in an attack on a town follows the same principles discussed in paragraphs 53, 54, and 55. During the advance toward the town, automatic weapons fire is directed against the near edge of the town with particular attention to enemy machine guns and predetermined key points of resistance. The automatic weapons are prepared to deliver fire on the flanks for protection against enveloping enemy counterattacks, fire down the streets to engage targets in or crossing the streets, and to establish a killing zone where the enemy may be driven by the attacking infantry. During mopping-up operations, the automatic weapons may be used to trail the infantry and provide support in the event

that organized resistance is met. Once within the town, positions may be selected in ruined buildings or behind street barricades.

90. JUNGLE WARFARE. a. Jungle growth and the resulting poor fields of fire and poor observation make the use of automatic weapons in close support a difficult problem. Within certain limitations they can be effective. When enemy resistance is definitely located, the automatic weapons can be moved into positions for effective fire. Often such a movement calls for much pioneer work and careful reconnaissance. Continuous support is impractical in most cases.

b. Because of their large volume of fire, automatic weapons are very useful in destroying bunkers and caves and in neutralizing enemy strong points.

91. ATTACK OF A RIVER LINE. The attack on a river line differs little from a normal attack. The automatic weapons that are to deliver supporting fires are located as close to the river as the terrain and the tactical situation will permit. They fire on known targets, with priority of fire on enemy machine guns and other automatic weapons. If the attack is to be a surprise operation, the automatic weapons stay to the rear until the attack begins; then they will move immediately to positions picked in an earlier reconnaissance. The automatic weapons cross the river as soon as is practicable in order to give support to the advancing infantry.

92. ATTACK OF A FORTIFIED POSITION. **a.** The destructive hitting power of antiaircraft automatic weapons is not sufficient for successful attack on a fortified position. However, they can be used to great advantage if properly employed.

b. Fortified positions normally are mutually supporting and the type of weapons vary from machine guns to large caliber, high velocity guns. Automatic weapons supporting an attack on such positions can aid the attack by directing their fire on apertures in the fortifications, thereby forcing their closure, and by concentrating their fire on the smaller emplacements of the fortified installations.

c. Emphasis is placed on the planning phase of the attack. Positions are carefully selected and prepared. Routes to these positions are selected and learned by the personnel. Movement into position should be during the hours of darkness and, if secrecy is desired, during artillery fire so the noise of the vehicles is drowned out.

93. BEACHHEADS. **a.** When automatic weapons are to furnish ground support to the infantry in an amphibious operation, the automatic weapons will land in the wave, or at the time, designated by the infantry commander. As soon as they are on the beach, the automatic weapons deploy to positions selected from the map. Their immediate targets are those which are holding up the infantry advance inland.

b. Control is centralized as soon as possible after landing. In the early phases of the operation, it

may not be possible to maintain centralized control; in such situations, the individual squad leader takes command.

c. Amphibious operations require careful planning and coordination. The automatic weapons platoon commander must know the infantry battalion mission and he must brief his men thoroughly on their jobs. Since ground reconnaissance is not possible, positions and routes to positions are selected from the map; terrain characteristics sometimes are studied from sand table reproductions of terrain.

Section IV. DEFENSE AGAINST MECHANIZED ATTACK

94. GENERAL. Automatic weapons can be an important part of an antimechanized defense. However, these weapons are not suitable as antitank guns; they are effective against lightly armored or unarmored vehicles only.

95. EMPLOYMENT. a. General. Automatic weapons must not be used as the primary weapons of an antimechanized defense. Their great fire power and accuracy do make them valuable supplementary weapons. They can be used very effectively for such tasks as—

(1) Causing enemy tanks to *button-up.*

(2) Knocking out periscopes of tanks.

(3) Attacking enemy infantry personnel accompanying tanks.

(4) Covering mine fields and road blocks.

(5) Attacking lightly armored vehicles in the armored column.

b. Reconnaissance. As soon as the automatic weapons commander knows the general defense plan, he makes a reconnaissance of the area he is to occupy and makes his recommendations to the commander responsible for the defense. On this reconnaissance, he locates the primary and alternate positions, routes to the positions, and the routes for his ammunition resupply.

c. Positions.

(1) The most likely positions for supplementing the antimechanized defense cover the probable avenues of approach of an enemy armored column.

(2) Since the automatic weapons are only a part of the defense, the positions are coordinated with the other weapons of the defense.

(3) The antiaircraft automatic weapons positions must be mutually supporting and zones must be established for each weapon so that adjacent weapons do not fire into each other.

(4) Since the antiaircraft weapons have little armor, the positions are dug in or built up so a poor target is offered the enemy and the gun crews have a maximum of cover. The positions are concealed and camouflage discipline is observed. Alternate positions are prepared and the plans for occupying them are made.

96. LIAISON. The automatic weapons commander establishes and maintains close liaison with the commander responsible for the defense. He must know the defense plan and the part he is to play in the coordinated defense.

97. CONTROL. To be effective, a defense must be coordinated and under a single command. The automatic weapons in an antimechanized defense are under the control of the commander who is responsible for the defense. The commander coordinates the weapons in the defense; he also assigns missions and targets to the antiaircraft automatic weapons.

Section V. ENGAGEMENT OF NAVAL TARGETS

98. GENERAL. In most situations, enemy naval activity near a defended shore will be accompanied by such aerial support that the use of antiaircraft artillery automatic weapons will be confined to the defense against air attack. However, there will be occasions when enemy naval operations are without aerial support. Examples of such operations are sneak raids on established installations and secret thrusts to reinforce beleaguered troops.

99. EMPLOYMENT. a. Targets. Naval targets suitable for antiaircraft automatic weapons are—

(1) Motor torpedo boats.

(2) Submarines.

(3) Landing craft.

(4) Lightly armored naval craft that operate near defended shores.

(5) Under-water demolition teams.

b. Reconnaissance. When the antiaircraft artillery automatic weapons are given a surface mission against naval targets, they are moved into positions suitable to their new mission. To accomplish this, the automatic weapons commander makes a reconnaissance to select positions and alternate positions, routes to the positions, routes for resupply, and locations for command posts.

c. Positions.

(1) Positions are as near the water level as practicable to take full advantage of the flat trajectory of automatic weapons.

(2) Positions are dug in or built up to offer the enemy a poor target and to afford the crew the most protection possible.

(3) If intelligence indicates a probable direction of approach, the positions must cover those approaches.

(4) The automatic weapons must be mutually supporting and have zones of fire so that no weapon will fire into adjacent weapons.

(5) If the automatic weapons are but a part of the defense, the positions are coordinated with other weapons of the defense.

100. LIAISON. The automatic weapons commander must establish and maintain close liaison with the

responsible commander. The plan for defense or for the prevention of reinforcing enemy troops must be known and the fire direction plan familiar to all key personnel. It is important that all personnel be kept familiar with the situation at all times.

101. CONTROL. **a.** When employed in rear areas, the antiaircraft artillery automatic weapons in an antinaval role probably will be under the control of a harbor defense commander. This commander will be responsible that the weapons are properly disposed and that the personnel are properly informed on the situation.

b. When employed in forward areas in an antinaval role, the automatic weapons may be under the control of any commander, most likely an infantry commander. Regardless of the situation, the commander responsible for the defense is responsible for the disposition of the antiaircraft weapons and their proper coordination.

CHAPTER 4

EMPLOYMENT OF AIRBORNE ANTIAIRCRAFT ARTILLERY

Section I. GENERAL

102. MISSION OF AIRBORNE FORCES. The mission of an airborne force is to attack, seize, and hold important objectives in enemy areas by executing an envelopment from the air, ordinarily in conjunction with other ground forces. This type of tactical operation involves troop movement by aircraft and/or gliders. If the landing area at the final destination has been secured from hostile small arms fire and artillery fire, the subsequent operations of airborne troops differ little from those of similar troops transported by other methods, except for the lack of organic transportation and the difficulty of supply.

103. MISSION OF AIRBORNE ANTIAIRCRAFT ARTILLERY UNITS. The mission of airborne antiaircraft artillery units is to provide local antiaircraft artillery defense of assigned installations against low-flying aircraft and to fire on mechanized or other terrestrial targets.

104. TRAINING. Airborne antiaircraft units receive the same training as other types of antiaircraft units with similar weapons. In addition they are specifically trained in the following:

a. Enplaning and deplaning of troops, equipment, and supplies—this includes practice loading in mock-ups, lashing of equipment, and computing of loads.

b. Planning and execution of operations requiring precise coordination with air forces, parachute troops, and other arms.

c. Administration, supply, and evacuation without normal motor transportation facilities.

d. Independent operation of squads, sections, and platoons.

e. Flight discipline before enplaning and also while in flight.

105. PLANNING. a. The success of airborne operations depends upon accurate and careful planning. These plans are flexible enough to allow for unexpected events and to allow enough time for briefing lower echelons.

b. In planning an airborne operation great use is made of maps, recent aerial photographs, and sand table reproductions.

c. Tentative positions are selected by map study and the terrain studied in detail by personnel. If the situation and plane space permit, an advance party is sent with the first elements to reconnoiter the selected positions and to act as guides for the units as they arrive.

d. During the entire planning phase, constant liaison is maintained with the force G–2. It is important that the latest enemy information be disseminated through the command.

e. Plans for the recognition and identification of aircraft must be in accordance with previously established principles. In the early stages of an airborne operation, the normal AAAIS and AAOC will be lacking.

f. Effective liaison between the transported units and the air forces is a prerequisite for a successful landing. There must be opportunities for practice and rehearsals.

g. Since the surprise element is of utmost importance, security measures must be complete. Great care is taken to conceal activities that would lead the enemy to believe that an operation is being planned.

h. The antiaircraft artillery automatic weapons airborne battalion is equipped with fifty-two caliber .50 machine guns on individual mounts. These weapons normally are transported with the assault echelon and are manned until the primary weapons are landed in the follow up echelons. At that time the primary weapons of the battalion may be used for antiaircraft artillery defense or in the surface mission as required and upon the decision of the force commander.

106. LOADING. a. Troop carrier aircraft have reinforced floors and built-in tie-downs. The loads are so positioned that no part of the floor is over-

loaded and the load so placed that the tie-downs are in effective position for securing the load. Rope usually is used to lash down the cargo, but a combination of rope and chain is used to lash heavy equipment such as trucks and guns.

b. Loading lists and tables are carefully prepared. Each individual responsible for the loading of an aircraft should have a list showing the men and the equipment to be loaded in that aircraft; he also makes certain that the necessary loading and lashing materials are at hand. All equipment, armament, and ammunition are inspected before take-off.

c. The Army commander in each aircraft is responsible for the proper placing and lashing of the load and the preparation of the flight manifest for his own aircraft. The flight manifest form, which must be checked and signed by the pilot, insures that the center of gravity falls within the proper area.

d. The troop carriers are combat loaded. Weapons, ammunition, rations, and other necessary materials are carried in the same plane with the operating personnel.

107. LANDING. a. Landings may be classified in two categories:

(1) Landing in an area that has been secured by friendly forces or is unopposed for other reasons.

(2) Landing in an area that is defended.

b. Antiaircraft artillery units that expect to land unopposed may be transported in powered aircraft or in gliders.

c. Antiaircraft artillery units accompanying primary weapons that expect opposed landings are transported in gliders only.

d. Upon landing, antiaircraft artillery protection may be needed for the landing area. In such a case, the first elements to arrive will set up a defense of the landing area. The remainder of the antiaircraft artillery elements move to their previously selected positions as soon as they land. Since speed is of primary importance, the antiaircraft artillery elements move by squad or section to their position; assembly of the entire battery would take too long.

Section II. EMPLOYMENT OF AIRBORNE ANTIAIRCRAFT ARTILLERY BATTALION

108. MISSIONS. On an airborne operation, the antiaircraft artillery automatic weapons may have an antiaircraft mission of defense against air attack or they may have a surface mission of defense against ground attack. The decision to divert the automatic weapons from the antiaircraft mission to a surface mission is determined by consideration of the greatest threat to the over-all mission of the force.

109. PRIORITIES. a. The airborne antiaircraft artillery automatic weapons battalion has only three firing batteries. Because of this small amount of

automatic weapons, great care is taken in their disposition. Priorities for defense against aircraft attack are established by the division commander. These priorities are based on the strength of the enemy air arm and the tactics used by it.

b. The following discussion indicates the type of installation that normally will receive priority for air defense. The order in which they are presented has nothing to do with their place on a priority list.

(1) *Air strip.* Once an air drop is made, emphasis is placed on strengthening the airhead. Usually an airstrip is the most vital installation of the airhead and, as such, has high priority. Even if the strip is nothing more than a rough field suitable for the landing of gliders, it requires protection to insure the safe landing of successive elements of the airborne operation.

(2) *Field artillery.* If the tactics of the enemy indicate probable attacks on the artillery, then the artillery has a high priority for defense against air attack. After the airhead has been definitely established and the infantry begins to move forward, the artillery becomes of increasing importance. At this stage of the operation, the artillery may have high priority.

(3) *Bridges.* An important part of an airborne operation is the union with troops moving overland. If bridges within the division area are a critical feature of this union, they may be high on the commander's priority list.

(4) *Communication center and command post.* Continued organization and coordination of the divisional elements are necessary in an airborne operation. The center of this is the division command post. If enemy aerial attacks upon command posts reach such intensity that control of the operation is jeopardized, the command post may be a high priority installation.

c. There are many elements of the airborne division that, because of their nature, rarely require antiaircraft artillery protection.

(1) *Ammunition and supply dumps.* In the initial stages of an airborne operation, ammunition and supplies are well scattered in small dumps and offer a poor target for an air attack.

(2) *Infantry.* The infantry personnel, except in their early organization on the ground, are dispersed and are able to protect themselves from air attacks by dispersion and concealment.

(3) *Motor parks.* The small amount of transportation in the airborne division relieves the problem of dispersion. It also is important to note that with this small amount of transportation, most of the vehicles are busy most of the time.

(4) *Small unit command posts.* These installations offer poor targets because they are small and are able to take full advantage of concealment and cover.

110. CONTROL. a. If the mission permits effective battalion control, the AAA battalion is controlled by its commander. If control can be better exercised by the defended units the batteries are attached for operational control to those units.

b. To enable the commander to organize and coordinate his unit on landing, he accompanies the leading elements of the unit. Likewise, the battery commander rides with the leading plane of his battery.

c. If enemy action or an accident delays or destroys the commander's plane, the senior antiaircraft officer on the spot assumes command and controls the battalion. The battalion staff always travels in two echelons to assure the arrival of a control headquarters.

111. DISTINCTIVE CHARACTERISTICS OF AN AIRBORNE ANTIAIRCRAFT BATTALION. **a.** Distinctive characteristics of the employment of airborne antiaircraft artillery are—

(1) Minimum communication facilities.

(2) Ammunition limitations and difficulty of resupply.

(3) All around security.

(4) Rapid movement with frequent changes of position.

(5) Movement by hand or limited motor transportation.

b. Airborne operations require greater physical exertion and necessitate proper physical condition.

112. AIR TRANSPORTATION. **a.** The leading elements of the airborne antiaircraft artillery battalion may accompany the parachute troops, but normally the heavy equipment is transported by glider; however, transport aircraft may be used if the destination provides a proper type field free from enemy action.

b. The range of an aircraft is dependent upon its load. As the payload of an aircraft increases, it decreases its fuel load; thus an aircraft with a light load can carry that load farther without refueling. If an airborne operation calls for a long aerial flight, that operation requires more planes than a similar operation of shorter range.

c. It is evident from the above discussion that each airborne operation requires a different number of planes. The air distance to the objective, the types of planes available, and the tactical requirements of the operation determine the amount of air transportation needed.

CHAPTER 5

OBSERVATION AND EARLY WARNING

113. GENERAL. Adequate warning of the approach of enemy aircraft is essential to the most effective utilization of antiaircraft artillery equipment and personnel. Without adequate warning all elements of the antiaircraft artillery defense would have to be maintained in a constant state of readiness. Such a state of readiness would require additional personnel to operate as reliefs and would require additional equipment for maintenance and replacement.

114. WARNING IN FORWARD AREAS. Antiaircraft artillery automatic weapons units operating in forward areas have a special problem in early warning. Even though these units are tuned in on the appropriate AAAIS net, it is possible that any warning from this source will be too late. With present equipment it is necessary for minimum crews to be on the weapons at all times; most of the warning will come from the air guards stationed on or near the individual weapons. Some situations may permit the use of a ring of observers around the defended area but, in many cases, the use of such observers is not feasible.

115. WARNING IN REAR AREAS. Antiaircraft artillery automatic weapons units in rear of the division area normally will be a part of an integrated defense in which an effective AAAIS is established. These units will be in this AAAIS net and will receive early warning from the appropriate AAOC.

116. AAOC's. AAOC's are established in the corps and army areas by the senior antiaircraft artillery headquarters in the respective areas. It is the responsibility of these headquarters to coordinate the defense of their respective areas and supply the early warning of the subordinate units. Communication is by wire and radio.

CHAPTER 6

PROTECTION AND SECURITY

117. GENERAL. Antiaircraft artillery units must be prepared to defend themselves at all times against an enemy attack. It is inexcusable for a unit of any type to be surprised and it is the responsibility of the commander to see that this does not happen.

118. PASSIVE DEFENSE. Passive defense may be defined as defense of a place without the employment of active weapons and without the expectation of taking the initiative. Defense is based on protection, deception, dispersion, and concealment.

a. Concealment. Unless the enemy knows the location of a unit, it cannot effectively attack that unit. Furthermore, concealment of individual units preserves secrecy and denies the enemy knowledge of vital operations. Concealment is obtained by use of natural or artificial camouflage. The actual concealment of installations and matériel is worthless unless the personnel are trained in camouflage discipline and this discipline is enforced.

b. Cover. Cover is necessary to protect matériel and personnel from shellfire, bombs, and other of-

fensive weapons. The amount of cover that the antiaircraft artillery can use is restricted by their mission. However, protection can be attained by building fortifications for weapons, shelters or slit trenches for personnel, and dugouts or the like for command posts. Maximum use of cover must be made.

c. **Dummy positions.** Dummy positions, if used properly, can do much to fool the enemy. If time permits, they can be made very realistic and may attract much enemy fire. These positions are so located that when they are attacked, real installations will not be damaged. The dummy positions are laid out as real ones and partially concealed to make them more realistic.

d. **Dispersion.** The problem of dispersion is one that needs to be considered carefully. Dispersion prevents large-scale damage during attacks, but it increases the problem of local security. The commander decides which danger is greater, air attack or infiltration. If the enemy has air superiority and is bombing regularly, the need for dispersion is emphasized. However, if the enemy uses infiltration tactics to a great degree, local security is made more effective by having installations and material concentrated.

e. **Night movement.** An important passive defense measure is movement by night. Such a movement enables a unit to change position without the observation or knowledge of the enemy. Night marches are most desirable in combat areas and should be used to the maximum extent. However

such marches are difficult and, unless properly made, are not worth the effort. For best effect, these marches usually are made with black lights, and often without any lights at all. On dark nights and over difficult terrain, the rate of march is slow and at times it is necessary to lead vehicles on foot. It is essential that drivers be alert so that they will not get lost or be separated from the column.

f. Black-out. An installation that is perfectly concealed during the daylight hours may be revealed at night if the smallest light is showing; even the glow from a cigarette can be seen from some distance on a dark night. It is vital that no unnecessary lights be used and that those which are necessary be properly blacked out. Command posts tents or shelters are checked frequently for light leaks and the entrances must have a light-lock.

g. Radio silence. Radio silence is imposed to deny the enemy knowledge of operations. It is essential that this silence, when imposed, be adhered to strictly. Enemy listening posts can trace the movements of a unit by listening to transmissions even though the messages are not understood or of any value. During the period of radio silence, communication is carried on by any other convenient means.

h. Warning signals. In combat, observation is of utmost importance. One of the many purposes of observation is to warn of enemy attack. Such warning often is issued in the form of warning

signals. These signals are standardized in various units so that a given signal indicates to all that a definite type of attack is about to occur. An example is the sounding of a percussion-type alarm as a signal for a gas attack.

i. Defilade. When in range of hostile artillery, defilade is of value in preventing damage to matériel and injury to personnel. Antiaircraft artillery weapons are so positioned that they are shielded from flat trajectory enemy artillery, but personnel are still able to see and shoot to the front. Defilade also may serve to hinder enemy observation.

119. LOCAL SECURITY. a. General. Local security includes all the measures necessary for the protection of personnel, equipment, and supplies from ground attack. It is accomplished by effective utilization of personnel and matériel available to the unit.

b. Types of attack. Antiaircraft artillery units can expect any of the following types of attack:

(1) Glider.

(2) Parachute.

(3) Infiltration.

(4) Reconnaissance in force.

(5) General break-through.

(6) Mechanized thrust.

c. Selection of position. An antiaircraft artillery position is selected with the mission as the guiding factor. However, the local security that can be at-

tained is an important consideration. Since these two points are not contradictory, they can be reconciled and both requirements satisfied. In considering the local defense that can be attained, the following factors are considered:

(1) Fields of fire for ground targets.

(2) Tactical advantage of ground.

(3) Routes of approach into and out of fire unit position.

(4) Observation.

(5) Camouflage.

d. Organization of position. The position is organized for all-around perimeter defense, utilizing primary armament, secondary weapons, and all available equipment. The defended area is kept as small as possible and, so far as is possible, all equipment is kept within the perimeter defense. Machine guns and rifles are sited to form bands of interlocking fire around the perimeter to prevent the enemy from penetrating the area.

e. Matériel. The weapons and equipment normally available to antiaircraft artillery units for local security and guides to the employment of this equipment are discussed below.

(1) *Machine guns.* Machine guns form the backbone of any ground defense. They are sited for interlocking, grazing fire along unobstructed lanes of fire. The far side of wire or other obstacles should have clearly defined fire lanes. To pre-

vent overheating of the machine guns on the multiple mount, only two guns are used at a time; as they heat, they are alternated with the other two machine guns. Machine-gun firing is delivered in short bursts. Alternate positions are selected and prepared.

(2) *40-mm guns.* The 40-mm gun, using high explosive ammunition, is particularly effective against personnel because of the air bursts that can be obtained on trees, underbrush, or growth in the path of enemy approach.

(3) *Grenades.* Grenades are a valuable weapon because they can be used without revealing the position to the attacker.

(4) *Mines and booby traps.* The great value of mines and booby traps is that they not only inflict casualties on the enemy, but also serve as a warning. Great care must be exercised in planting mines or booby traps because of the danger to friendly personnel. Mines usually are laid in bands far enough outside the defended area so their explosion will not injure friendly personnel. Trip flares often are used instead of mines when friendly personnel frequent the area of the defense.

(5) *Barbed wire.* The purpose of a wire obstacle is to provide warning and delay the enemy. Wire is placed around the position from 30 to 100 yards from the

equipment and may have noise-making devices attached to it; this distance is selected so that the enemy cannot effectively attack with grenades from the other side of the obstacle. Details on the construction of wire obstacles are given in FM 5–15.

(6) *Individual arms.* Rifles, carbines, and submachine guns are used from foxholes to cover wire and other obstacles. Small arms positions are organized so as to provide flanking fire and crossfire; riflemen are placed to provide local protection for the machine guns.

(7) *Rocket launchers.* Units in forward areas provide antimechanized defense by locating rocket launchers on the probable avenues of approach. Rockets whose ammunition has been modified by ordnance to give supersensitive detonation also are effective against personnel.

(8) *Rifle grenades.* Rifle grenades are effective against personnel and lightly armored or unarmored vehicles. They have added value because of the long range effect.

f. Standing operating procedure (SOP). An SOP is essential for every unit regardless of size. It is coordinated with higher and adjacent units and must be understood by every individual in the unit. It includes provision for—

(1) Establishment and execution of the local security plan immediately on occupation of position.

(2) Marking of restricted areas which include mines and booby traps.

(3) Submission of mine and booby trap reports.

(4) Alert signals.

(5) A mobile reserve to support units which need aid.

(6) A system of challenges, passwords, and replies.

(7) Manning primary equipment and ground defense in the event of an alert.

(8) Ground observation and listening posts.

(9) Rules governing the opening of fire on ground targets.

(10) Individual ammunition supply and an ammunition reserve.

g. Plan. Immediately upon occupation of a position, a local security plan is put into operation. The plan must be simple and flexible. It makes provision for—

(1) Establishment of an all-around perimeter defense.

(2) Siting of weapons.

(3) Fields of fire for all weapons.

(4) Establishment of guards and listening posts.

(5) Detail of guards, length of tour, special orders, and method of changing guards.

(6) Location of booby traps and mines to be installed.

(7) Stations of personnel when alert is sounded.

(8) A definite procedure in case of a perimeter penetration.

(9) Location of obstacles to be constructed.

(10) Location of sleeping stations.

(11) Location and type of foxholes to be dug.

(12) Areas to be restricted.

(13) Regulations for night movement.

(14) Preparation of firing lanes.

(15) Method of communication.

(16) The order in which work is to be done.

h. Conduct of defense. Antiaircraft artillery automatic weapons have a special problem in local security. In many cases, each fire unit is far enough separated to require its own defense. The limited manpower of a fire unit makes the security of the unit a real problem. One man is kept alert at all times; if an infiltration is likely, alternate men on the perimeter remain alert. These men on the perimeter conduct the defense with hand grenades until the enemy penetrates the perimeter or until he is definitely located. Premature firing with the primary weapons is avoided to prevent the location of these weapons by the enemy. If the attack

cannot be stopped by grenades or small arms fire, the 40-mm gun or the multiple machine-gun mounts are brought into action. In a given area, adjacent antiaircraft artillery automatic weapon fire units can give flanking fire to each other. This fire is planned during the daylight hours and stops are prepared to prevent firing into friendly personnel.

CHAPTER 7

RECONNAISSANCE, SELECTION, AND OCCUPATION OF POSITION

Section I. GENERAL

120. GENERAL. This section establishes the principles employed in the reconnaisance, selection, and occupation of positions by antiaircraft artillery automatic weapons in the antiaircraft mission. The problems met while operating in the surface mission are not discussed in this chapter.

121. RECONNAISSANCE. **a.** The purpose of reconnaissance is to obtain accurate information about the terrain over which the antiaircraft artillery automatic weapons are to operate.

b. Reconnaissance may be made by one of three methods or any combination thereof.

(1) A map reconnaissance implies that maps are used to study the topographical features of the terrain, the road nets, and natural obstacles. Tentative positions for fire units and the routes to be used are determined by use of maps. However, maps in themselves are not entirely sufficient and need to be supplemented by other means.

(2) Aerial reconnaissance is a decided advantage when time and equipment permit it. The greatest value of an aerial reconnaissance is to supplement a map reconnaissance. It gives the commander an opportunity to study and further evaluate the terrain he has studied on the map. It also gives the commander an appreciation of the terrain held by the enemy, and may indicate any recent changes not shown on current maps.

(3) The ground reconnaissance is the most important type of reconnaissance and always is made when the tactical situation permits. The purpose of ground reconnaissance is to—

(*a*) Verify by actual observation the suitability of positions and routes tentatively selected by map study.

(*b*) Plan in detail the organization and occupation of the positions selected.

(*c*) Plan and initiate, if possible, the communications net.

c. Time is a controlling factor in any reconnaissance. The more time that is available, the more complete the reconnaissance can be. It is desirable for the battalion commander and the battery commanders to make a ground reconnaissance, but often time is so pressing that the actual physical reconnaissance of individual gun positions is delegated to platoon officers or noncommissioned officers.

d. An individual making a reconnaissance must keep in mind the ideal characteristics of a position. He will never find such a position, but by demanding the best he will be able to locate his unit in the most desirable spot in the assigned area. It must be remembered that every possibility is a compromise between the terrain and the requirements of a good position.

122. SELECTION AND OCCUPATION OF A FIRING POSITION. **a.** Selection of a firing position entails consideration of two conflicting requirements—field of fire and concealment. The field of fire is the governing factor.

b. A good position—

(1) Permits a wide sector of fire. A 360° field of fire is desirable, whenever possible.

(2) Allows guns to fire at lowest elevation.

(3) Affords maximum concealment possible consistent with antiaircraft artillery mission.

(4) Affords good ground cover.

(5) Is situated to take advantage of ground protection afforded by other troops.

(6) Is situated so that equipment can be moved out quickly.

(7) Is mutually supporting with other fire units.

c. The manner in which a position is occupied is the problem of the fire unit leader. If time permits, the position is studied to discover the best way to

occupy it with the least possible damage to the existing terrain. The actual emplacement of the weapons is the first consideration; camouflage and improvement of the position continue as long as it is occupied. The route to the position should be a covered one, if it is at all possible, and any marks or newly-made trails are removed; revealing tracks must not be visible from the air. Vehicles are dispersed and concealed as much as is consistent with local security. Camouflage discipline must be enforced.

123. FIELD FORTIFICATIONS. a. Field fortifications are designed for the protection of matériel and personnel from high explosive demolition bombs, antipersonnel bombs, strafing attacks, or artillery fire.

b. Fortifications may be dug in, built up, or a combination of both, but in any case, fortifications should be up to the gun trunnion height (FM 5–15).

124. DISPLACEMENTS. Whenever an antiaircraft unit moves, there are certain plans laid out to facilitate movement. The selection of the following will facilitate the movement and control of the unit on the march:

a. IP—Initial point.

b. RP—Release point.

c. Report center (RC). This is a point where the battalion commander or his agent can be contacted at any time during the move. It is a vital link in

the chain of communication between the closing of the old command post and the opening of the new command post. It is selected from a map and should be a clearly defined point both on the map and on the ground.

d. Assembly area. This is a place selected for guns and trucks to assembly before the march actually starts. It is here that the column is formed and instructions are given. This area should offer cover and concealment and be near a good road network.

e. Lost-vehicle rendezvous. This is a point near the new area where vehicles that are lost or left behind report, to wait for a guide to conduct them to the new area. It is selected from a map and should be a well-defined spot both on the map and on the ground.

f. Emergency-assembly area. This area is to be used in the event that the selected positions cannot be occupied. This area also is selected from a map and should be easily recognized on the ground. This area has the same general characteristics as an assembly area.

g. Route instruction card. This card, issued one per vehicle, is a description of the route to be followed. It contains names of towns, distance between towns, turns, crossroads, and other information helpful to the individual drivers and section leaders.

Section II. MOBILE UNITS

125. BATTALION COMMANDER'S RECONNAISSANCE.

a. General. Battalion reconnaissance is the direct responsibility of the battalion commander. He makes a study of the terrain from a map or aerial photograph and selects tentative position areas for all the elements of his command.

b. Routes. The battalion commander determines the routes to be used by his units in moving to the new position. If the move is to be by battalion, he determines the initial point and the release point. Between these points, he checks the routes to locate hazards and condition of roads; he also checks possible alternate routes.

c. Communication. The report center is the vital link in the communication chain while the battalion is on the road. This may be supplemented by radio or messenger. The battalion commander designates an officer to establish communication from his new command post to the fire units.

d. Battalion commander's party. It is desirable to take many officers and men on a reconnaissance, but the tactical situation seldom permits more than the necessary few. The following list indicates the key personnel actually needed on the reconnaissance; this list is increased or decreased according to the demands of the tactical situation.

(1) Battalion commander.

(2) S–3.

(3) Communication officer.

(4) Battery commanders or representatives.

(5) Guides, messengers, and agents.

126. BATTERY COMMANDER'S RECONNAISSANCE.

a. Purpose. The purpose of the battery commander's reconnaissance is as follows:

(1) To verify his map study.

(2) To actually select on the ground the gun locations, command post location, headquarters installations, and routes to the new area.

(3) Often, time does not permit the battery commander to make a complete reconnaissance and visit each gun position before it is occupied. In such cases, it is necessary for him to depend upon his platoon officers and noncommissioned officers to select the actual positions from tentative locations picked on the map.

(4) It is the responsibility of the battery commander to coordinate the positions of his unit and to assign sectors of fire to each fire unit. Laying out these sectors is an important phase of the reconnaissance.

b. Procedure. While the battery commander is on reconnaissance the executive officer is in charge of the unit. During the battery commander's absence, the executive briefs the unit on the movement, designating such points as lost-vehicle rendezvous, emergency-assembly areas, and assembly areas. If the unit moves before the return of the battery commander, the executive conducts the march to the new area and meets the battery commander at a designated rendezvous.

c. Battery commander's party.

(1) Platoon commanders.

(2) Communication sergeant.

(3) One or more privates to be used as messengers and guides.

127. PLATOON COMMANDER'S RECONNAISSANCE.

a. The platoon commander on his reconnaissance selects—

(1) Positions for each fire unit and its field of fire.

(2) Routes to positions.

(3) Location of platoon command post and observation post.

b. Unit positions. The platoon commander also determines positions for the following elements of each firing unit:

(1) Gun, director, and power plant.

(2) Multiple mount machine guns.

(3) Antiaircraft lookouts.

(4) Truck park and bivouac.

(5) Ammunition storage.

c. Procedure. When sufficient time is available, the platoon commanders accompany the battery commander on reconnaissance. All positions are visited and fields of fire coordinated. When time is limited, the platoon commanders, accompanied by the fire unit leader, make the reconnaissance and select and lay out the positions in accordance with

the orders received from the battery commander. In extreme cases, the platoon commander may designate the positions and general lay-out of the fire unit, while the actual selection of positions on the ground is made by the fire unit leaders. Fire unit leaders guide the units into position and supervise the occupation of position.

128. BATTERY COMMAND POST. The battery command post is located at a point which facilitates the establishment of communication with the platoons. If the battery is attached to a larger unit, its command post normally is at or near the command post of the unit to which the battery is attached.

129. PLATOON COMMAND POST. The platoon command post is located where the fields of fire of the greatest number of the platoon weapons may be observed. If the platoon is attached to a larger unit, its command post normally is located at or near the command post of the unit to which attached.

130. CONSIDERATIONS AFFECTING SELECTION OF POSITIONS FOR ANTIAIRCRAFT ARTILLERY AUTOMATIC WEAPONS. a. Field of fire and observation.

(1) Each antiaircraft artillery automatic weapons fire unit is given a normal and contingent zone, both for observation and fire, so that, regardless of the direction of approach of enemy planes, they can be observed and fired on. All units main-

tain constant observation over their normal sectors regardless of the sector in which their weapons are engaged.

(2) The 40-mm guns are located where they have a clear field of fire against both air and ground targets. Where all-around visibility cannot be secured, antiaircraft lookouts are placed on the far side of obstructions and communications established.

(3) The director is emplaced 13 to 15 feet from the gun in order to minimize parallax. The director is never to be emplaced lower than the gun level and preferably is emplaced from 1 foot to not more than 2 feet higher than the gun.

(4) The power plant has a connecting cable which permits an offset from the gun of about 225 feet.

(5) The multiple machine-gun mount is employed as a separate weapon. As stated previously, its greatest value is its ability to track high speed close-in targets. As long as the weapons in the unit are mutually supporting and the dead areas of 40-mm guns are covered, the multiple machine gun mount is not limited in its action to supporting the 40-mm gun.

b. Firm and level ground for emplacing the director and gun. The ideal location for the gun and director is on firm and level ground. Fairly level terrain enables leveling of the equipment without grad-

ing, and firm ground prevents the gun and director from changing level during firing. The tactical situation dictates the terrain in which a firing unit is located but, whenever possible, level and firm ground is selected.

c. Concealment from ground and air observation. When time and the situation permit, the selected position is camouflaged before it is prepared and occupied. It is of little value to camouflage a position after it has been located by the enemy.

d. Protection from artillery fire. Positions in the immediate vicinity of road intersections and other points subject to interdiction and harassing fire by hostile artillery are to be avoided, whenever possible. When the enemy becomes aware of a position, it is wise to move to an alternate position.

e. Cover. Immediately after a position has been selected, steps are taken to provide cover for the protection of personnel and matériel. Fox holes or slit trenches are dug by all personnel not actually engaged in manning the guns. Gun crews in action depend upon the fortification for protection. If the position is within range of hostile artillery, fox holes are prepared for all personnel.

f. Elevated sites. In defending objectives in or around urban areas, it often is impossible to find positions on the ground which provide the required fields of fire for the guns. In such cases, suitable sites may be found on tops of buildings of heavy construction. When antiaircraft artillery automatic weapons are placed on tops of buildings or other structures, shock absorbing platforms for the director are provided to prevent interfer-

ence by gun vibrations. In residential districts or where proper type buildings are not available, towers may be constructed and equipment placed on them with ramps or cranes. The bottoms of the towers are closed to provide loading spaces and housing. The towers should be high enough to give the desired field of fire and they are placed within mutually supporting distance; the tactical principles for disposition of tower-sited weapons are the same as for automatic weapons in their normal position on the ground. Disadvantages of tower-sited weapons are their inability to fire on low-flying enemy planes and their immobility.

131. OCCUPATION OF POSITION. The platoon commander issues instructions to each fire unit leader, giving the position for the gun and its dead area, time and rate of march, and any other instructions necessary to insure timely arrival and employment of the fire unit. Occupation of position is directed and supervised by the fire unit leader.

Section III. SELF-PROPELLED ANTIAIRCRAFT ARTILLERY UNITS

132. BATTALION COMMANDER'S RECONNAISSANCE. Self-propelled antiaircraft artillery units usually operate in fast moving situations and the batteries and platoons normally are quite scattered. In such operations, the battalion commander rarely can make ground reconnaissance. He is limited to the use of maps only and has to assign his units routes and areas from this map study.

133. BATTERY COMMANDER'S RECONNAISSANCE. The battery commander of a self-propelled unit may have his platoons so separated that he is not able to make a ground reconnaissance for all his unit's positions. For those positions which he is unable to visit, he depends upon his platoon commanders and noncommissioned officers. Much of the battery commander's work is confined to map study and his decisions are based on this study and on instructions from higher headquarters.

134. PLATOON COMMANDER'S RECONNAISSANCE. The real job of ground reconnaissance falls on the platoon commander. On his reconnaissance, the platoon commander selects—

a. Positions for each fire unit.

b. Routes to positions.

c. Location of security outpost.

d. Location of platoon command post.

e. Location of platoon ammunition supply point.

135. SECTION LEADER'S RECONNAISSANCE. The section leader, whenever possible, reconnoiters his position before moving in the vehicles. He determines—

a. Exact location of position and alternate position.

b. Exact route to position.

c. Routes away from position.

d. Concealment for ammunition trailers.

e. Means of camouflage.

Section IV. ANTIAIRCRAFT ARTILLERY AIRBORNE UNITS

136. RECONNAISSANCE. Reconnaissance for antiaircraft artillery airborne units is accomplished by detailed study of all available material on the terrain in which the unit is to operate. This includes a study of maps, aerial photographs, and sand table reproductions of the area, and all available intelligence. Each squad is given detailed instructions regarding the position it will occupy on arrival. This type of reconnaissance must be well planned and complete in every phase.

137. OCCUPATION OF POSITION. Upon arrival at the objective, speed is the primary requisite. The carriers are unloaded quickly. The squads determine their positions and move into them as rapidly as possible. The weapons are emplaced first and then, as time permits, the positions are improved by fortifications and camouflage.

138. ALTERNATE POSITIONS. Airborne units must have alternate positions to move into if the occupied positions become untenable. Alternate positions are prepared and improved as time and personnel become available. These alternate positions have the same tactical requirements as primary positions.*

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*After landing, airborne antiaircraft artillery follows the same general principles of employment as the towed or self-propelled antiaircraft artillery in similar situations.

CHAPTER 8

COMMUNICATIONS

Section I. GENERAL

139. GENERAL. **a.** Antiaircraft artillery communications comprise all the means employed to transmit orders, intelligence, and commands between antiaircraft artillery units and for liaison with units of other arms and services.

b. Within the various antiaircraft artillery units, communication is needed between the various command posts and with service elements for normal command and administration. In addition, the ability of an aircraft to attack from any direction, and its great speed and maneuverability, require an intelligence net (AAAIS) that will give timely warning of the approach of hostile aircraft. In the lower echelons, communication must be established for the conduct of fire and for the antiaircraft artillery guards.

140. NATURE AND EXTENT OF COMMUNICATION SYSTEM. A selection of the agencies to be employed and the extent to which the communication system will be installed in any situation depend upon the following factors:

a. Facilities available.

b. Frequency of movement.

c. Dispersion of units.

d. Terrain and atmospheric conditions.

e. Secrecy restrictions.

Section II. RADIO COMMUNICATION

141. MOBILE AUTOMATIC WEAPONS BATTALION. a. Higher headquarters net. The SCR–188 is in the group command net when the battalion is operating with a group; when the battalion is not operating with a group, this radio is tuned to the command net of the appropriate higher headquarters. It operates on a frequency assigned by the higher headquarters concerned.

b. Battalion command net. The battalion command net includes one AN/GRC–9 at battalion headquarters and one AN/GRC–9 at each of the firing batteries. The radio at battalion headquarters is the net control station (fig. 23).

c. Battery command net. The battery command net includes one AN/GRC–9 at battery headquarters and one AN/GRC–9 at each of the platoon headquarters. Since the mobile battalion normally is committed as a battalion, it is desirable that each of the firing batteries be allocated a different frequency for the battery command net. If such frequencies are not available, it will be necessary for the battalion net control station to control the radio communication (fig. 23).

d. AAAIS net. The battalion has eight AN/GRC–9's for use in the AAAIS net. These

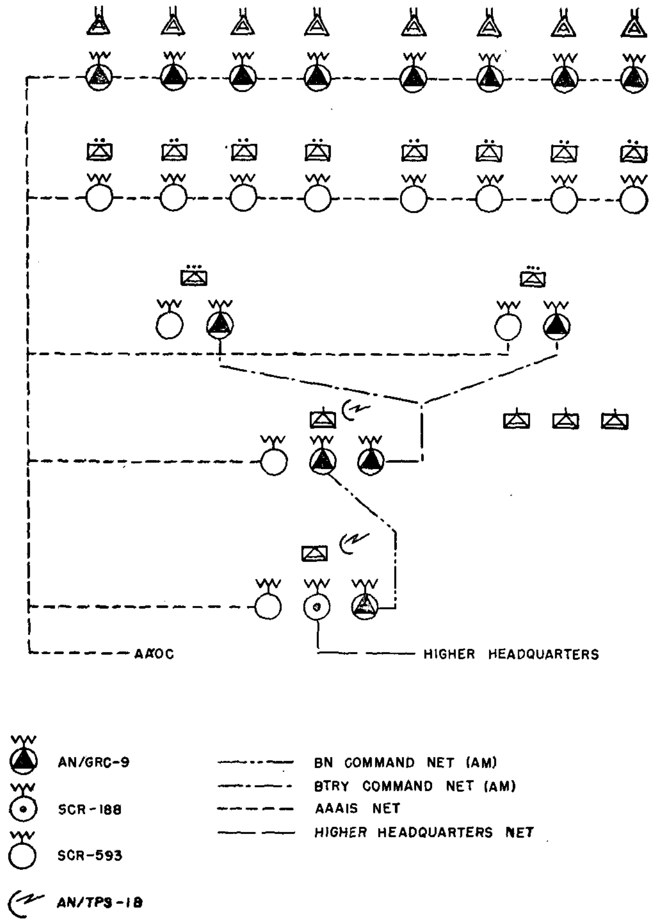

Figure 23. Radio net for a mobile automatic weapons battalion.

radios are used at an observation post and normally are on a common frequency established by the senior headquarters of an integrated defense. When the battalion is operating alone, the AAAIS is operated by the battalion. To receive AAAIS warning, the battalion headquarters has one SCR–593 and each firing battery has nineteen SCR–593's; the SCR–593's in the battery are located at battery headquarters, platoon headquarters, and one at each fire unit (fig. 23).

142. SELF-PROPELLED AUTOMATIC WEAPONS BATTALION. a. Higher headquarters net. The self-propelled battalion has one SCR–506 which is used in the group command net when the battalion is operating under group control. When the battalion is not under group control, this radio set is used to communicate with the next higher headquarters. This radio set normally is located in the battalion communications section (fig. 24).

b. Battalion command net. The battalion command net includes all the firing batteries and staff sections of the battalion (fig. 24). The radio sets in this net and their locations follow:

(1) The battalion net control station has one SCR–508 located in the communication section.

(2) The battalion commander has an SCR–508 in his command vehicle.

(3) Each of the firing batteries has one SCR–508 in the battery headquarters vehicle.

(4) The battalion S–4 has an SCR–510 mounted in his vehicle.

(5) The S–2, S–3 section has one SCR–528 mounted in the operations vehicle.

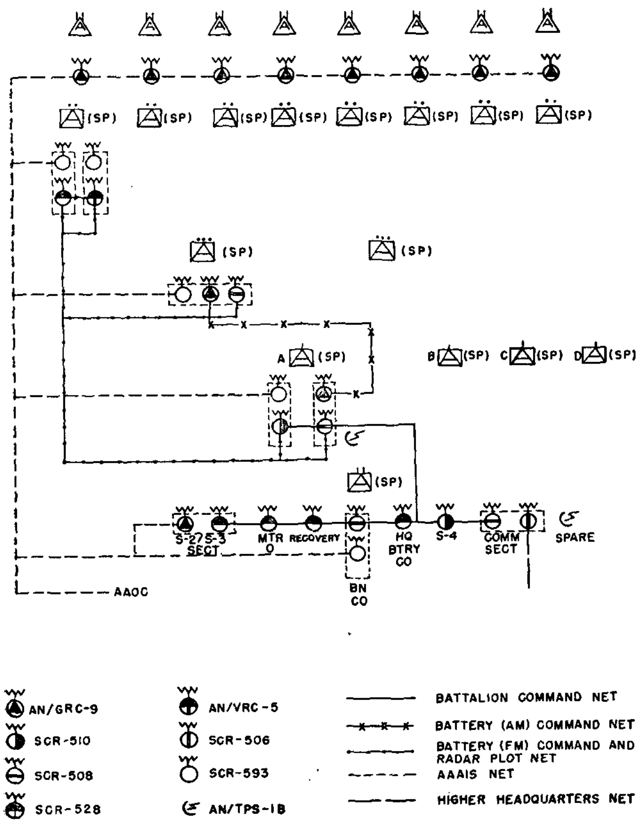

Figure 24. Radio net for a self-propelled automatic weapons battalion.

(6) The headquarters battery commander has one SCR–528 in the headquarters battery vehicle.

(7) The battalion motor officer has one SCR–528 in his vehicle.

(8) One SCR–528 is mounted in the tank recovery vehicle.

(9) The SCR–510, mounted in each battery commander's ¼-ton vehicle, has its alternate channel tuned to the battalion command net.

c. **Battery command net.** There are two battery command nets—one is an amplitude modulated (AM) net and the other is a frequency modulated (FM) net. The AM command net includes one AN/GRC–9 at battery headquarters and one AN/GRC–9 at each of the platoon headquarters. This net is used when the battery is spread so far that the FM radios are outranged. The FM net includes one SCR–508 at battery headquarters, one SCR–508 at each of the platoon headquarters, one SCR–528 at each multiple machine-gun mount M16, and one AN/VRC–5 at each gun motor carriage M19. There is one SCR–510, located in the ¼-ton vehicle, on the battery FM net (fig. 24).

d. **AAAIS net.** The battalion has eight AN/GRC–9 radio sets that are used at observation posts. These sets are on a frequency established by the AAOC when the battalion is operating with corps. When the battalion is with a division, warning is direct to the battalion. The battalion head-

quarters has one SCR–593 to receive AAAIS warning; each firing battery has one SCR–593 in battery headquarters, one in each platoon headquarters, and one in each fire unit (fig. 24).

e. Close support net. This net is ordinarily a platoon net, used when the platoon is in close support

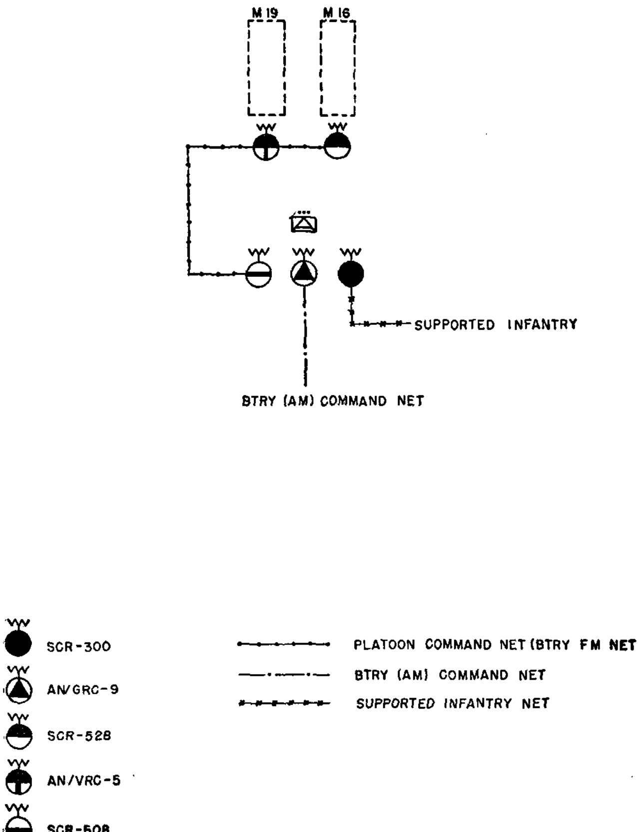

Figure 25. Close support radio net.

of an infantry unit. The close support net includes an AM channel, using AN/GRC–9's for communication with battery headquarters. The SCR–300 is used on the infantry command net. The platoon fire control net is the FM net of the battery, using the SCR–300 at platoon headquarters and the SCR–528 and AN/VRC–5 at the fire units (fig. 25).

143. COMMUNICATION IN THE AIRBORNE BATTALION. The airborne antiaircraft artillery uses both wire and radio as means of communication. In the early phases of an action, radio likely will be the primary means of communication. The airborne battalion has enough radio sets to establish a satisfactory system of communication. Reference to figure 26 will show the following nets:

a. Higher headquarters net. One of the AN/GRC–9's at battalion headquarters is tuned to the frequency of the higher headquarters command net. This set also is used as an emergency AM set on the battalion command net.

b. The other AN/GRC–9 at battalion is the broadcast station for the AN/TPS–1B and is tuned on the AAAIS frequency.

c. The battalion command net (FM) includes one SCR–619 at battalion headquarters and one SCR–619 at each of the firing batteries.

d. Each battery has an FM command net composed of one SCR–619 at battery headquarters and one SCR–619 at each platoon headquarters.

e. In battalion headquarters, there is one SCR–619 reserved for communication with a supported unit.

f. The AAAIS net is composed of SCR–593's at battalion, battery, platoon, and firing section.

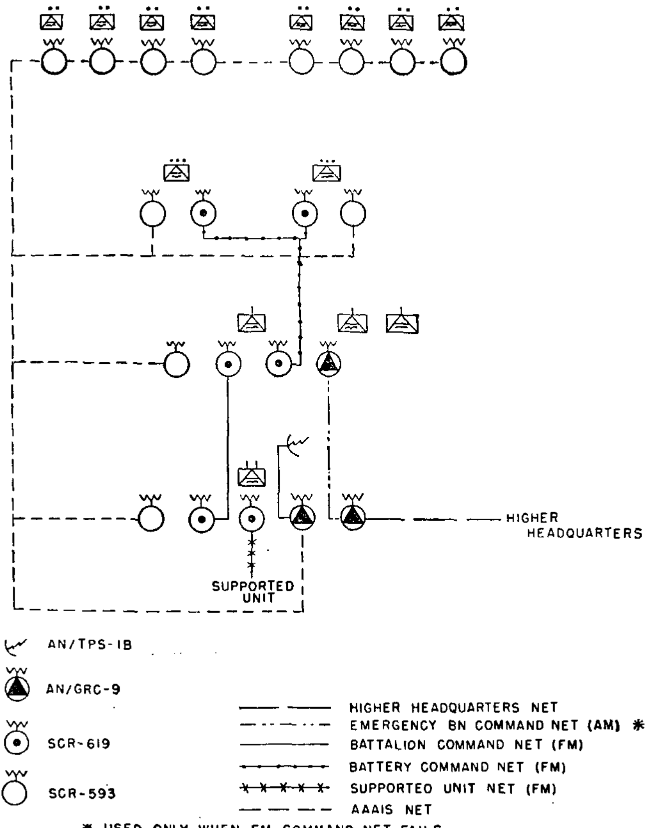

Figure 26. Radio net for airborne automatic weapons battalion.

These sets are tuned on the broadcast frequency of the AN/GRC–9 which gives warning of air attack.

144. COMMUNICATION WITH OTHER BRANCHES. There are times when the antiaircraft artillery automatic weapons will operate with units other than antiaircraft artillery. Radio communication becomes a vital problem at such times. There are two methods of establishing radio communications with other type units; if the radio sets are of the same type with overlapping channels, assignment of an overlapping channel will provide for communication. Often, the radio sets are not alike and do not have overlapping channels; under such conditions it will be necessary to trade radios so that each unit has the same type.

Section III. WIRE COMMUNICATION

145. GENERAL. Wire communication equipment provided by the tables of organization and equipment is sufficient to install essential lines between command posts, within the batteries, and for interior lines necessary for fire control of the various elements. Any additional equipment needed may be drawn from the Signal Corps supply depots. The extent to which wire communications are installed is governed by the tactical mission of the unit. The wire communication net of a unit employed in a static situation should be as complete and extensive as time and material permit. The wire communication net of a unit employed in

a mobile situation, where frequent changes of position are involved, necessarily will be limited by the requirements of the situation. Wire communi-

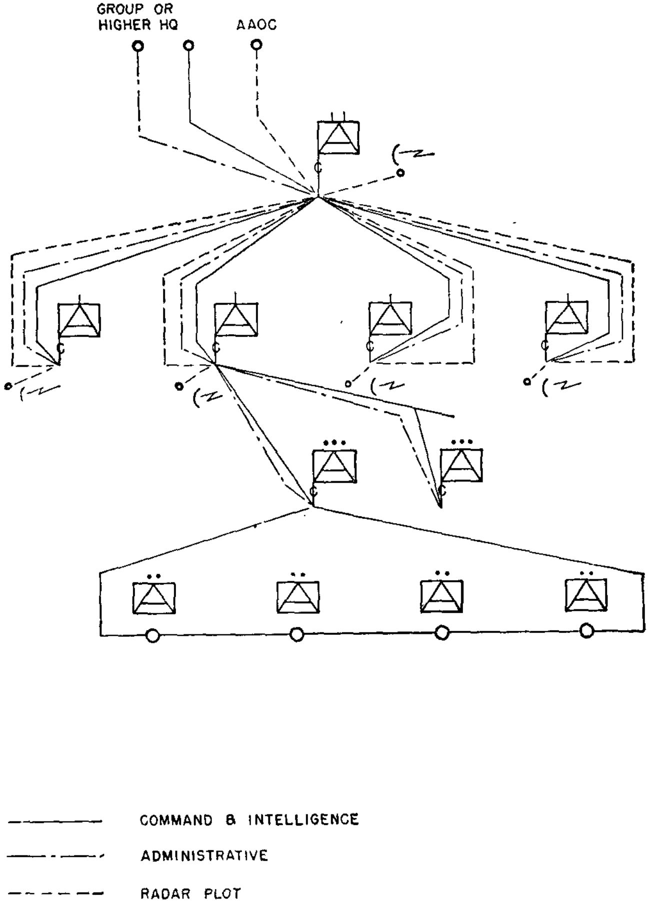

Figure 27. Wire net for a mobile automatic weapons battalion.

cation is the most dependable means of communication and every effort must be made to utilize it to the fullest extent. In the early stages of an operation or in a rapidly moving situation, radio must furnish the initial means of communication; but, as time and circumstances permit, wire should be laid to supplement the radio net. Figure 27 shows a type wire net for an antiaircraft artillery automatic weapons battalion.

146. AIRBORNE OPERATIONS. Because of the limited amount of wire and equipment that can be carried, every effort must be made by all commanders to conserve wire. The need for wire communication to each installation must be considered carefully. Command posts are located as near as possible to subordinate units in order to reduce the length of wire circuits. Wire circuits must be carefully laid and protected. Since no provision is made for a wire communication crew within the battery, personnel from the gun sections are trained to establish, operate, and maintain wire communications and to operate the radio.

CHAPTER 9

TRANSPORTATION

147. GENERAL. The proper use of available transportation in the field is an important consideration. This chapter is a general discussion of the transportation problems of the antiaircraft artillery automatic weapons battalion.

148. TRANSPORTATION AVAILABLE. Reference to the current T/O&E's shows the transportation available to each type unit. The transportation allotted the mobile units is liberal enough for normal situations. However, the self-propelled units are limited in cargo trucks and must, of necessity, carefully plan the use of these vehicles. The most difficult transportation problem faces the airborne battalion which, because of its very nature, has little organic transportation.

149. USE OF VEHICLES. a. Mobile units. In the mobile units, each gun section, supply section, and maintenance section is supplied with its own vehicles. With proper organization and use, the transportation is sufficient for the section's needs; the fuel allotment, rather than the number of vehicles, is the restricting factor.

b. Self-propelled units. In the self-propelled units, each weapon has only its gun motor carriage and trailer. All the matériel and personal equipment is carried on the vehicle or its trailer. This requires careful loading plans and the elimination of all unnecessary materials. The two cargo trucks available to the battery have to take care of supply, mess, and maintenance.

c. Airborne units. The small amount of organic transportation in the airborne unit makes the use of any vehicle a critical problem. The use of available vehicles is planned in advance and the plan rigidly adhered to. If the unit remains in combat for an extended period, it must be provided with additional vehicles or have its needs cared for by other units. Captured vehicles are especially useful to airborne units.

150. LOADING PLANS. To provide for the transportation of all necessary matériel and personnel, it is necessary that loading plans be made for all antiaircraft artillery units. Through the use of loading plans, units may move with a minimum of effort and a maximum of efficiency.

CHAPTER 10

SUPPLY, MESSING, AND EVACUATION

Section I. SUPPLY

151. GENERAL. This section covers the supply of all antiaircraft artillery automatic weapons units. Basic supply procedures and definitions are contained in FM 100–10 and FM 101–10.

152. SUPPLY AGENCIES. a. Mobile, self-propelled, and airborne antiaircraft artillery battalions have the personnel and transportation required to draw and deliver all classes of supply. Antiaircraft artillery groups do not carry supplies for the battalions, but do coordinate the supply activities of subordinate units.

b. Supplies which are procured by requisition are first requisitioned by the batteries. The battalion supply officer consolidates these requisitions and forwards them through appropriate supply channels. When the battalion is under an antiaircraft artillery group, a copy is sent to the group headquarters for follow up and information.

c. When requisitioned supplies become available, each supply unit is notified, in turn, down to battalion level. The drawing of and distribution of

the supplies are covered by the supply plan of the higher headquarters. The battalion supply section distributes supplies to subordinate units.

153. CLASS I SUPPLIES (RATIONS). The forward flow of rations normally is automatic, based on daily battalion consolidated reports of actual strength. A daily train carrying the needed supplies from depots in the communications zone is sent forward for each division and for corps and army troops. Upon arrival at the railhead, the rations are picked up by the battalion supply sections.

154. CLASS II SUPPLIES (SUPPLIES AND EQUIPMENT PRESCRIBED BY THE TABLES OF ORGANIZATION AND EQUIPMENT). These supplies are requisitioned, drawn, and distributed as described in paragraph 152**b**.

155. CLASS III SUPPLIES (GASOLINE AND OIL). The army quartermaster establishes gasoline and oil supply points at all railheads and depots, or at convenient locations such as civilian gasoline filling stations on the main supply route. Each vehicle sent to an army supply point replenishes its supply at a convenient gasoline supply point at or en route to the army supply point. Vehicles remaining in the forward area are resupplied by exchanging empty containers for full ones brought forward from gasoline and oil supply points by unit transportation.

156. CLASS IV SUPPLIES (ARTICLES OF MISCELLANEOUS NATURE). Supplies such as construction materials are requested by special requisitions. The receipt and delivery of these supplies are the same as for class II supplies.

157. CLASS V SUPPLIES (AMMUNITION). Below the army level, units maintain a continuous supply of ammunition by replenishment of basic loads.* The maintenance of basic loads is the responsibility of the unit commander. The supply installation supporting the unit will fill transportation orders received bearing the statement "Required to replenish basic loads; expenditures are within authorized available supply rate".

158. VARIATIONS IN SUPPLY CAUSED BY TACTICAL EMPLOYMENT. When antiaircraft artillery automatic weapons batteries and platoons are given separate missions and attached to other units, supply functions usually are performed by the unit to which they are attached.

159. SUPPLY FOR AIRBORNE ANTIAIRCRAFT ARTILLERY UNITS. a. General.

(1) The supply of airborne units follows normal procedure in that higher headquarters is responsible for the delivery of supplies to troops that have landed by air. Until unit ground troops have effected a junction with airborne troops,

*The basic load is the amount of ammunition expressed in rounds by type which can be carried by a unit in its organic transportation provided by tables of organization and equipment.

supplies for airborne troops are transported by air.

(2) The supply plan for an airborne operation includes the determination of a stockage level of all classes of supplies to be concentrated in rear airdromes. A balanced portion of all classes of this stockage is packed for parachute delivery to be available on call for supply by parachute to any unit for which no other method of supply exists.

(3) A quartermaster depot supply company, trained in aerial supply, prepares these supplies for movement by transport plane or for delivery by dropping. This unit handles all classes of supply.

(4) Additional labor and transportation for the assembly of supplies at the departure airdromes and their preparation for delivery by air are made available from quartermaster service companies and Transportation Corps truck companies.

b. Supply within airborne division. Upon the arrival of supplies at the destination landing areas, the division supply services assume control, and the distribution of supplies within the airborne division follows normal procedure. The limited transportation that can be effected by air demands the use of all tactical transportation within the division, and all captured enemy vehicles, to effect prompt distribution of supplies. Units within the division normally dispatch transportation back to

the division supply points near the destination area for all classes of supply.

c. Antiaircraft artillery battalion supply.

(1) Airborne antiaircraft artillery units carry in their organic tactical loads an initial supply of ammunition for every weapon to be used. This initial supply is the basic load. The basic load is established by the Department of the Army and issued concurrently with tables of organization and equipment. Supplies carried by the airborne antiaircraft artillery units are limited, and can be expected to suffice for a short time only. Personnel must be trained to use all supplies sparingly, especially in the early stages of an airborne mission when resupply is extremely difficult.

(2) An initial supply of rations, water, and gasoline also is included in the tactical loads of the units. Rations are carried by the individual. Water is carried by the individual and supplemented by the supply carried in the unit loads. Gasoline is carried in the unit loads.

Section II. MESSING

160. GENERAL. The antiaircraft automatic weapons battalion has a special problem in messing in the field. The individual battery in tactical position is often so widely dispersed that it is difficult

for the battery mess section to supply them with warm food. In addition, the policy of constant alertness makes it necessary for a part of each gun section to be at the position continually. The solution of the problem rests with the commanding officer; he uses the available equipment in the best manner that the tacitcal situation will permit.

161. MESS EQUIPMENT AUTHORIZED. a. Field ranges and accessory equipment. The field range and its associated equipment offers a good solution to the messing problem when it is practical for the entire unit to mess together. If the gun positions are close enough for the men to come to battery headquarters for mess, the problem is solved satisfactorily.

(1) Following are the advantages of this system:

(*a*) Battery mess personnel prepare food for the entire unit.

(*b*) Food preparation is best available.

(*c*) It closely parallels the garrison mess system.

(*d*) It relieves untrained personnel of the responsibility of food preparation.

(*e*) It enables proper cleansing of individual mess equipment.

(2) The disadvantages of this system are as follows:

(*a*) Battery personnel coming to mess in shifts cause each meal period to be extended longer than usual.

(*b*) It endangers security in forward areas by the amount of foot traffic moving about.

(*c*) It causes a concentration of personnel about the battery headquarters area.

(*d*) It takes personnel away from the guns for some time.

b. Insulated containers. This equipment is used in conjunction with the normal mess equipment. The food is prepared by the battery mess personnel and transported to the gun positions. The containers keep the food warm for a period long enough to serve the entire unit.

(1) Advantages of this method of messing are as follows:

(*a*) Gun details remain in the vicinity of their weapons.

(*b*) It prevents concentration of personnel in one spot.

(*c*) It lowers the amount of traffic in the battery area.

(*d*) It speeds up the time required to feed the unit.

(2) Disadvantages of this method are as follows:

(*a*) It is possible only where vehicular traffic is unrestricted.

(*b*) Proper cleaning of individual mess equipment is difficult.

(*c*) It is difficult to ration food so that the last section served has as much as the first sections served.

(*d*) It makes camouflage discipline more difficult.

(*e*) It makes additional work for mess personnel.

(*f*) Very often food can be delivered only in hours of darkness.

c. Cooking outfit for small detachment. This equipment is authorized for each gun section and is complete enough to prepare properly the type of rations normally issued in the field. The T/O&E provides for no additional personnel for this equipment; therefore, it is necessary for the members of the gun crew to do the cooking. When this method of mess preparation is used the mess steward must break down the rations to the gun sections.

(1) The advantages of this method are as follows:

(*a*) It makes hot food accessible when the fire unit is far removed from the battery headquarters.

(*b*) It eliminates traffic between headquarters and gun positions.

(*c*) It makes fire units more self-sufficient.

(*d*) It eliminates concentration of personnel at battery headquarters.

(*e*) It provides a method for making emergency rations more palatable.

(2) The disadvantages of this method are as follows:

(*a*) Personnel of gun crews are not trained cooks.

(*b*) Proper cleaning of mess equipment is difficult.

(*c*) Mess supervision is difficult.

(*d*) It makes camouflage discipline more difficult.

(*e*) No refrigeration equipment is available; perishable foods must be kept at headquarters mess until just before preparation.

162. MESSING WITH OTHER UNITS. When an antiaircraft artillery automatic weapons unit or parts of the unit are separated from organic messing facilities, it may mess with adjacent units. This can be accomplished by attaching for rations the automatic weapons unit to the adjacent unit; it also can be accomplished by diverting the automatic weapons units rations to the preparing unit.

Section III. EVACUATION

163. GENERAL. For complete information see FM 100–10, FM 8–5, and FM 8–10.

164. MEDICAL PERSONNEL ATTACHED TO ANTIAIRCRAFT ARTILLERY UNITS. Each separate antiaircraft artillery automatic weapons battalion has attached

medical personnel; the automatic weapons battalion organic to the division has no medical detachment. For command purposes, and for administration and supply, the battalion medical detachment is an integral part of the battalion.

165. ORGANIZATION DURING COMBAT. a. The battalion aid station detail supervises the medical service of the battalion. It is organized to provide an administrative, supply, and evacuation service for the battery aid details. It establishes and maintains battalion aid stations and dispensaries. It cares for and treats troops located in the vicinity of battalion headquarters. It directs and supervises the dental service of the battalion.

b. A battery aid man is attached to each battery to provide dressings and first aid.

166. FUNCTIONING DURING COMBAT. a. In general, the tactics employed by combat units determine the medical service plans to be employed by attached medical units.

b. In the field, the battalion aid station is established at or near the antiaircraft artillery battalion headquarters. From this position, the surgeon maintains contact with battalion headquarters and with each battery aid detail. He supervises, reinforces, and, to a limited degree, supplies these aid details with medical supplies and materials.

c. Aid stations must not be established near ammunition supply points nor in proximity to the designated parking places for artillery vehicles.

Every effort must be made to remove them from possible attack by enemy air or artillery. They may be established near roadways, but never at important points such as road intersections and crossroads. A road in the immediate vicinity of an aid station facilitates evacuation by ambulance.

d. During periods of activity the aid men live with the batteries to which they are attached, and return to their sections only when the battalion is brought together for rest or training. When a battery remains in one position for a considerable period of time, battery aid men obtain a small surplus of medical supplies with which to establish local aid posts near the battery positions. Battery aid men care for the casualties occuring in the battery and take posts in the vicinity of the guns when the battery is firing or receiving hostile fire. Casualties are promptly removed to a place of safety, given medical aid, and carried or directed to an aid station. Evacuation from the battalion is as directed from higher headquarters. In stabilized or partially stabilized situations, the battery aid men are required to report at least once daily to the battalion aid station to give information and receive instructions.

CHAPTER 11

TARGET PRACTICE

Section I. GENERAL

167. GENERAL. The purpose of this chapter is to outline in general form the conduct of antiaircraft artillery automatic weapons target practice. Details as to recommended procedures, forms for scoring, and procedure in scoring will be found in TM 44-234.

168. SCOPE OF PRACTICE. A practice for automatic weapons normally consists of three antiaircraft artillery service practices, followed by a record service practice. An antimechanized practice will be included if facilities are available.

169. PURPOSE OF PRACTICE. Target practice for antiaircraft artillery automatic weapons has the following specific purposes:

a. To develop teamwork among members of the unit.

b. To develop leadership in company grade and noncommissioned officers.

c. To test the efficiency of the unit's training.

170. NORMAL REQUIREMENTS. **a.** The automatic weapons battery normally fires all firing sections prescribed by the unit table of organization and equipment. If a shortage of personnel makes this impracticable, the following formula is used to determine the minimum number of firing sections required to be fired:

(1) For a 40-mm battery—Average present for duty strength multiplied by .9 divided by 15.

(2) For a self-propelled battery — Average present for duty strength multiplied by .9 divided by 12.

b. Drill procedure as laid down by appropriate service of the piece manuals must be followed.

c. For aerial targets, the ground speed of the towing aircraft must exceed 200 miles per hour. Firing is conducted on both the right to left and the left to right courses.

d. Any requirement that cannot be met must be explained as directed by TM 44–234.

Section II. ANTIAIRCRAFT ARTILLERY PRACTICE

171. GENERAL. **a. Familiarization fire.** This type of fire is conducted to familiarize the crews with the firing of their weapon and in the use of the sighting systems.

b. Fire unit supervision. A qualified officer, preferably an officer of the platoon to which the fire unit belongs, must be present at the weapon during the firing.

c. Critiques. A critique will be conducted at or near the gun site immediately following each course on which a weapon has fired. All members of the fire unit participate in the critique. The officer exercising supervision of the fire unit conducts the critique.

172. SERVICE PRACTICE. a. General. Machine guns may be fired on the same courses with the 40-mm gun. They also may be fired on alternate courses of a practice, or a separate practice may be conducted for each type of weapon. Personnel are rotated so that more than one member of the crew becomes proficient in key duties. Trial fire and test fire are allowed prior to the practice. The crew is under complete control of the commander and, except for minimum safety control, he is allowed freedom of action.

b. Normal requirements for service practice.

(1) *Towed target firing.*

(*a*) A minimum of one incoming and two crossing courses are fired by each weapon using the primary sighting system.

(*b*) A minimum of one incoming and two crossing courses are fired by each weapon using the more important secondary sighting system.

(2) *Rocket or radio controlled aircraft firing.* Two crossing, diving courses are fired by each weapon.

(3) The altitude of one course for each gun will be less than 400 yards or at the minimum altitude prescribed by the tow target squadron commander.

(4) The towed flag target is based for 40-mm guns and the towed sleeve target for machine guns. Rockets and radio controlled aircraft are used as targets for all automatic weapons.

(5) Requirements for the three service practices are the same except that in service practice number 3 the speed ring sight on the 40-mm gun is used instead of the more important secondary sighting system.

173. RECORD SERVICE PRACTICE. **a.** The record service practice is fired under the supervision of a higher headquarters. Each weapon will fire the required courses. Record service practice requirements will be published from time to time by the Department of the Army.

b. Recommended conditions for record service practice.

(1) A minimum of one incoming and two crossing courses are fired by each weapon using the primary sighting system. A towed target is used for this firing.

(2) A minimum of one incoming and two crossing courses are fired by each weapon using the most important secondary sighting system. A towed target is used for this firing.

(3) Two crossing, diving courses are fired by each weapon. A radio controlled aircraft target is used for this firing.

(4) The altitude of one course for each weapon will be less than 400 yards or at the minimum altitude prescribed by the tow target squadron commander.

(5) The towed flag target is used for the 40-mm guns and the towed sleeve for machine guns.

Section III. ANTIMECHANIZED PRACTICE

174. GENERAL. If an antimechanized range is available, this practice will be fired.

175. CRITIQUES. A critique is conducted at or near each weapon immediately following each course fired by the weapon.

176. SERVICE PRACTICE. a. Normal requirements.

(1) A minimum of three courses are fired by each automatic weapon using the sighting system normally used for antimechanized fire. One weapon will fire at a time.

(2) At least two changes over 60° in direction per course are required.

(3) The range limits are 400 yards maximum to 150 yards minimum for machine guns, and 600 yards maximum to 200 yards minimum for the 40-mm guns.

(4) The target should be 12 feet long, 7 feet wide, and 5 feet high.

(5) Minimum speed must not be less than 15 miles per hour.

b. Records. See TM 44–234.

Section IV. SAFETY FOR ANTIAIRCRAFT ARTILLERY AUTOMATIC WEAPONS PRACTICE

177. GENERAL. The automatic weapons firing range is under the control of the chief safety officer. No gun will be fired until he indicates that the field of fire is safe; this condition is indicated by flying a large red flag from the central safety tower. For details concerning safety, refer to SR 385–310–1 and TM 44–234.

178. SAFETY DETAILS. The chief safety officer has a detail to aid him in maintaining safety precautions on the firing range. There is stationed at each weapon firing one officer who acts as line of metal officer. It is the duty of this line of metal officer to mark off the safety limits for his particular weapon and to insure that the weapon is not traversed beyond those limits. He also is responsible that the weapon is not pointed beyond the prescribed distance along the towline. He does not permit his weapon to fire until the red flag of the chief safety officer is raised. The number of safety officers needed to assist the chief safety officer is determined by the type of range and the number of units firing; it always must be sufficient to maintain safe conditions for antiaircraft artillery practices.

PART TWO

FIRE CONTROL AND GUNNERY

CHAPTER 12

INTRODUCTION

179. THE AUTOMATIC WEAPONS PROBLEM. Fire control devices for automatic weapons are designed to combat a fast-moving, low-flying target in rectilinear flight at a constant speed. This type of target precludes complicated fire control equipment which can produce round for round accuracy. Therefore, automatic weapons fire control devices depend upon traps, or fly-throughs, along the course of the target. These fly-throughs are portions along the target course where the fire control devices generate accurate hitting data. The problem is one of being alert and ready for action at all times, and when actually engaging a target, to obtain fly-throughs.

180. BALLISTICS. Ballistics is the science of the motion of projectiles. It is the basis of the art of gunnery and is divided into three parts—internal ballistics, exterior ballistics, and the ballistics of penetration.

a. Interior ballistics is the study of the motion of the projectile while still in the bore of the gun, together with the chemical and physical phenomena which cause and attend this motion. It provides a determination of the relationship between the powder, the projectile, and the gun. It includes the velocity of the projectile and the corresponding powder gas pressure at any point in the bore, with particular reference to the muzzle velocity and maximum pressure. Its chief application is in problems of design and manufacture.

b. Exterior ballistics is the study of the motion of the projectile after it has left the gun. Its practical application is the calculation of trajectories, the construction of firing tables, and computation of other data essential to the solution of gunnery problems.

c. Ballistics of penetration is the study of the motion of the projectile as it forces its way into solid substance such as armor and concrete. From this study it is possible to determine when to use a solid shot, when to use a high explosive shell, and when to use a combination of the two.

181. STANDARD TRAJECTORY. a. The path of the center of gravity of a projectile in flight is called the trajectory. The standard trajectory is defined as the trajectory described by a projectile under conditions which are assumed to be standard. The calculation of the standard trajectory is the primary problem in ballistics. Standard conditions are enumerated in firing tables. The projectile in

flight is acted upon by two forces—the force of gravity and air resistance.

b. Air resistance results in retardation of the projectile. When a projectile is fired from a gun, it possesses a certain amount of kinetic energy. A portion of this energy is used to overcome the forces of the air which retard it. The causes of retardation are as follows:

(1) The displacement of a certain volume of air from the path of the projectile.

(2) The skin friction between the surface of the projectile and the air.

(3) The formation of eddy currents around the projectile.

(4) The formation of a partial vacuum in rear of the projectile.

(5) The wave motion set up in the air by the projectile.

(6) Gyroscopic wobbling.

c. The effect of the above causes of retardation varies with—

(1) The relative velocity between the projectile and air which takes into consideration—

(*a*) The motion of the air (wind).

(*b*) The rotation of the projectile which tends to create a greater retardation effect due to the turbulence of the air.

(*c*) The speed of the projectile. As its speed decreases, air resistance decreases.

(2) The condition of the air as determined by such factors as air temperature, barometric pressure, and humidity. Ballistic density is derived from these factors.

(3) The size, weight, and shape of the projectile. These characteristics of the projectile are combined to facilitate calculations and are expressed by a single number called the ballistic coefficient (C), which is considered as a measure of the ability of the projectile to overcome air resistance. The value C is expressed: $C = W/id$; where W is the weight of the projectile in pounds; d, the diameter in inches; i, the coefficient of form. The value of i is determined empirically, based on an arbitrarily chosen shape of a projectile which is assigned a coefficient of 1.

d. As automatic weapons have such a short effective range and time of flight, the path of the projectile resembles a straight line (fig. 28).

e. The calculation of trajectories is performed by the Ordnance Department. The standard equations of applied mechanics are supplemented by empirical formulae derived as a result of experimental firings.

182. BASIC CONSIDERATIONS. **a.** The primary target for antiaircraft artillery automatic weapons

is a fast-moving, hard-hitting aircraft which often uses natural terrain to conceal its approach. Large caliber guns cannot cope with such a target.

b. Time is essential in the antiaircraft artillery automatic weapons problem. Frequently, the target must be taken under fire immediately after it has been observed to insure hits before it completes its mission or flies out of range. Continuous and rapid changes in time of flight and angular travel cause rapid changes in basic firing data. Some data

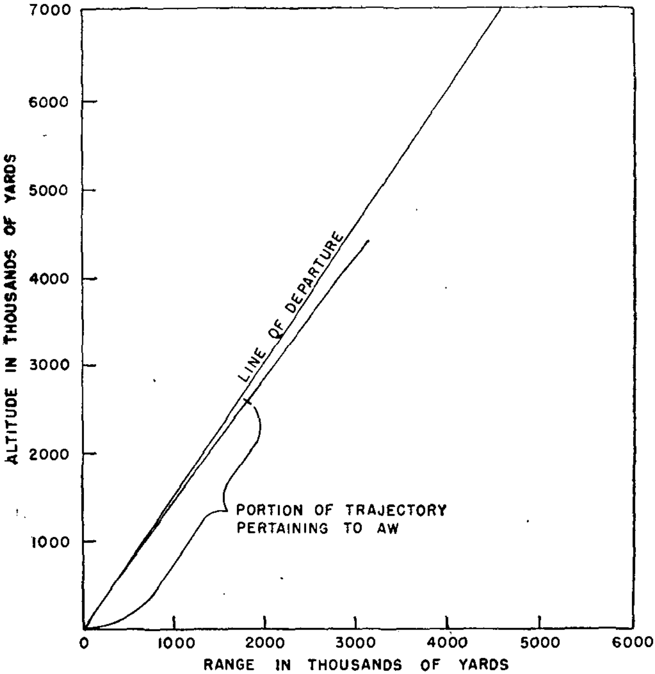

Figure 28. Trajectory for automatic weapons.

must be estimated. The time factor demands that estimates be almost instinctive. This can be accomplished by careful study, understanding the problem, and training.

c. To effectively engage the automatic weapons target, the gun employed must be accurate and flexible. It must have a high muzzle velocity and a high rate of fire. Present automatic weapons fulfill these qualifications to a marked degree.

183. GUNNERY FACTORS. a. Unlike gunnery for the large caliber antiaircraft artillery guns, the antiaircraft artillery automatic weapons must secure a direct hit to destroy the target. To hit a fast moving target, the automatic weapons must be pointed the correct distance ahead of the target and along the direction of flight.

b. The tolerances within which fire must be controlled to obtain a hit are the across-course (line) and along-course (lead) aiming tolerances. These are established by the size of the target. The depth normally is 2 to 3 yards and the length 15 yards. The across-course tolerance depends upon the target depth. Thus, for a 2-yard depth at 1,000 yards the angle subtended by the target is 2 mils. Assuming that the center of target is being tracked, the tolerance on either side of center is 1 mil. At 2,000 yards the tolerance is only ½ a mil. The along-course aiming tolerance is much greater as a 15-yard at 1,000 yards subtends 15 mils. The aiming tolerance is about 8 mils on either side of center. Of the two tolerances mentioned, the across-course aiming tolerance is more difficult to satisfy.

c. Automatic weapons gunnery principles are based upon the slant plane concept. This concept is the study of the light antiaircraft artillery problem by isolating all fire control requirements except superelevation into one plane, the slant plane. This slant plane is established by the target course line and the pintle center of the gun bore. By this concept, the axis of the gun bore, disregarding superelevation, is placed within the slant plane. When this is accomplished and superelevation disregarded, there is only one lead angle, the angle between the line of sight and the axis of the gun bore. Superelevation is considered separately from the lead angle.

CHAPTER 13

ELEMENTS OF DATA

184. SYSTEM OF SYMBOLS. **a.** In antiaircraft artillery, the elements of data are expressed by the use of symbols. Both English and Greek letters are used as symbols and prefixes to symbols. English letters and numbers are used as subscripts and superscripts to the symbols.

b. The subscripts *o* and *p* are used with *T* to indicate, respectively, the position of the target at the instant of firing (present position) and the predicted future position. These same subscripts are used similarly with *D*, ε, and *t* to indicate the particular element corresponding to the two positions of the target. The subscript *s* is used to indicate a slant plane element of data.

c. Symbols

Symbol	*Name*	*Definition*
A	A	Azimuth.
A_f	A sub f	Firing azimuth.
A_o	A sub o	Azimuth to present position.
A_p	A sub p	Azimuth to future position.
α_s	Alpha sub s	Slant plane angle of approach.
D	D	Slant range.
D'	D prime	Slant range in thousands of yards.

Symbol	Name	Definition
D_m	D sub m	Minimum slant range.
D_o	D sub o	Slant range to present position.
D_p	D sub p	Slant range to future position.
Δ_s	Delta subs	Lead angle.
Δ_G	Delta sub G	Generated lead angle.
Δ_R	Delta sub R	Required lead angle.
Δ_R^N	Delta sub R superscript N	Required lead angle for nose hit.
Δ_R^T	Delta sub R superscript T	Required lead angle for tail hit.
δ	Small delta	Lead angle in horizontal.
ε	Epsilon	Angular height.
ε_0	Epsilon sub o	Angular height to present position.
ε_p	Epsilon sub p	Angular height to future position.
ε_s	Epsilon sub s	Slant plane angular height.
G	G	Gun position.
γ	Gamma	Angle of dive.
γ_a	Gamma sub a	Apparent angle of dive.
γ_s	Gamma sub s	Slant plane angle of dive.
H	H	Altitude.
H_o	H sub o	Altitude at present position.
H_p	H sub p	Altitude at future position.
L	L	Target length.
λ	Lambda	Cone of sight angle.
LOS	LOS	Line of sight.
ϕ	Phi	Quadrant elevation.
ϕ_s	Phi sub s	Superelevation.
R	R	Horizontal range.
R_o	R sub o	Horizontal range to present position.
R_p	R sub p	Horizontal range to future position.
S	S	Speed of target along its course line expressed in yards per second.

Symbol	*Name*	*Definition*
S_X^N	S sub x superscript N	Speed setting for nose hit.
S_X^T	S sub x superscript T	Speed setting to hit tail.
Σ	Sigma	Rate of change.
Σ_a	Sigma sub a	Rate of change of azimuth.
Σ_e	Sigma sub e	Rate of change of elevation.
σ	Small sigma	Lead angle in vertical.
T_G	T sub G	Ground intersection of target course.
T_m	T sub m	Midpoint position of target.
T_o	T sub o	Present position of target.
T_p	T sub p	Future position of target.
t	t	Time of flight.
t_f	T sub f	Fly-through time.
t_o	t sub o	Time of flight to present position.
t_p	t sub p	Time of flight to future position.
t_x	t sub x	Selected time of flight.
t_p/D_p	t sub p over D sub p	Reciprocal of average shell speed.
t_p/D_p^F	t sub p over D sub p superscript F	Fixed value of reciprocal of average shell speed.

185. USE OF SYMBOLS. The symbols in paragraph 184 are used in the discussion of antiaircraft artillery automatic weapons gunnery that follows in this manual. They provide a means for expressing the fundamental concepts of gunnery in a clear concise manner by means of equations and expressions. They are used for brevity and clarity and it is necessary to have a working knowledge of

them to properly understand and use the terms in automatic weapons gunnery.

186. DEFINITIONS. a. Planes.

(1) *Horizontal plane.* The plane containing the pintle center of the gun and all points at that same elevation, assuming no curvature of the earth.

(2) *Slant plane.* The slant plane is that plane containing the target course line and the pintle center of the gun.

(3) *Shooting plane.* The shooting plane is that plane containing the line of sight and the axis of the gun bore, disregarding superelevation.

b. Points.

(1) G. G is the pintle center of the gun.

(2) T_o. T_o is the position of the target at the instant a round is fired.

(3) T_p. T_p is the point on the course line where a properly aimed round fired with the target at T_o would hit the target.

(4) T_m. T_m is the point on the course line at minimum range to the gun.

c. Lines.

(1) *Course line.* The course is the extension of the line T_o T_p indefinitely both ahead and astern of the target. The target course line is the same as the target path when the target moves in a straight line.

(2) *Line of sight.* The line of sight (*LOS*) is the line from G to T_o; this also may be referred to as slant range to present position (D_o).

(3) *Line of future position.* The line of future position is the line from G to T_p; this may be referred to as slant range to future position (D_p).

d. Angles.

(1) ε_o. ε_o is the vertical angle between the line of sight and the horizontal plane.

(2) ε_p. ε_p is the vertical angle between the line of future position and the horizontal plane.

(3) ε_m. ε_m is the vertical angle between the line from G to T_m and the horizontal plane.

(4) ε_s. ε_s is the dihedral angle between the slant plane and the horizontal plane.

(5) ϕ_s. ϕ_s is the angle of elevation placed on the gun to compensate for the curvature of the trajectory.

(6) ϕ. ϕ is the angle between the axis of the gun bore and the horizontal plane.

(7) α_s. α_s is the angle, not greater than 180°, measured between G, T_o, and T_p.

(8) Δ_R. Δ_R is the angle between the line of sight and the line of future position.

(9) Δ_G. Δ_G is the angle between the line of sight and the axis of the gun bore, disregarding superelevation.

e. Types of courses.

(1) *Level.* In a level course the target is flying at a constant altitude.

(2) *Diving.* In a diving course the target is flying with altitude decreasing.

(3) *Climbing.* In a climbing course, the target is flying with altitude increasing.

(4) *Incoming.* An incoming course is one in which the target is flying toward the gun. ($\varepsilon_s = 90°$.)

(5) *Outgoing.* An outgoing course is one in which the target is flying away from the gun. ($\varepsilon_s = 90°$.)

(6) *Crossing.* A crossing course is any course not incoming or outgoing.

(7) *Directly at the gun.* This type of course is one in which the target is flying toward the pintle center of the gun.

(8) By combining the above type courses, any target course can be described; for example, "Incoming Diving," "Crossing Level," or "Level Directly at the Gun."

CHAPTER 14

FUNDAMENTALS OF ANTIAIRCRAFT ARTILLERY AUTOMATIC WEAPONS GUNNERY

187. GENERAL. The primary target for antiaircraft artillery automatic weapons is a fast-moving, low-flying target in retilinear flight moving at a constant speed. Therefore, the automatic weapons fire control problem is simply this, "Upon what principles must all automatic weapons sights be built in order to produce hits on this primary target."

188. THE GUNNERY CHAIN. a. General. The four links of the gunnery chain are the four requirements which all antiaircraft artillery automatic weapons must satisfy in order to produce hits. The four requirements are called *links of the gunnery chain* because they have the characteristics of a chain in that all links are equally important. In the evaluation of any sighting device, if one requirement is poorly met, the entire sighting device is weak.

b. Links of the gunnery chain.

(1) Link I—Establish the line of sight.

(2) Link II—Establish the shooting plane in the slant plane.

(3) Link III—Establish the correct lead.

(4) Link IV—Establish the correct superelevation.

189. LINK I—LINE OF SIGHT. The line of sight is established by the continuous tracking of the gun pointer. The gun pointer places his sight upon the target and maintains that contact (fig. 29). The accuracy of alinement depends upon the skill of the tracker, as well as upon the design of the sighting device.

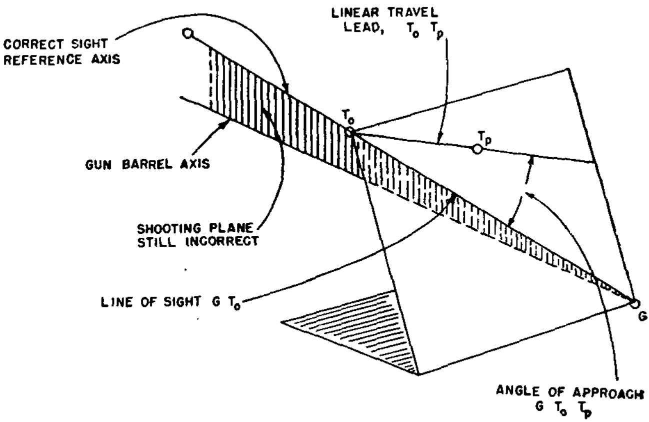

Figure 29. Link I—Line of sight.

190. LINK II – SHOOTING PLANE IN THE SLANT PLANE. a. In figure 30, consider a thin flap attached to the line of sight by hinges so that it can be rotated about this line. Consider further that

the axis of the gun bore, disregarding superelevation, lies in this flap. The flap then would be the shooting plane. To establish the shooting plane in the slant plane, rotate this flap about the line of sight until it lies in the slant plane. This operation is accomplished by the sight operator with the aid of the sighting device.

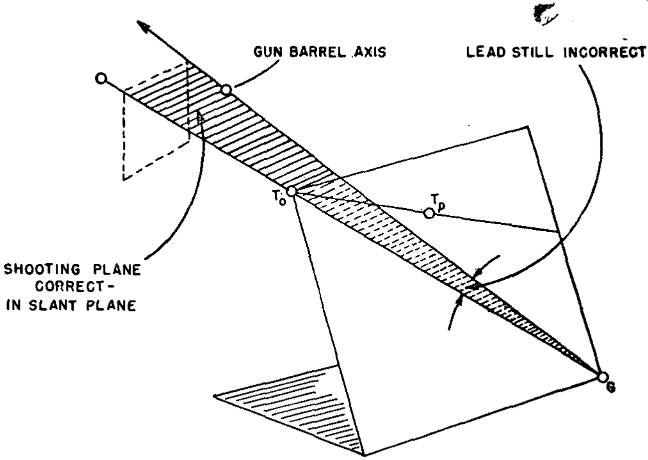

Figure 30. Link II—Shooting plane in the slant plane.

b. The tolerance in establishing Link II is the across-course aiming tolerance. The across-course aiming tolerance is one-half the small angle subtended by the depth of the target; this tolerance is very small, one or two mils at the most.

191. LINK III—LEAD ANGLE. a. The correct lead angle is established by the sight operator when he puts into the sighting device proper values for either slant range or target speed (slant range for

director controlled fire and target speed for on-carriage sights). As the sight operator adjusts range or speed in the sight, he varies Δ_G (fig. 31).

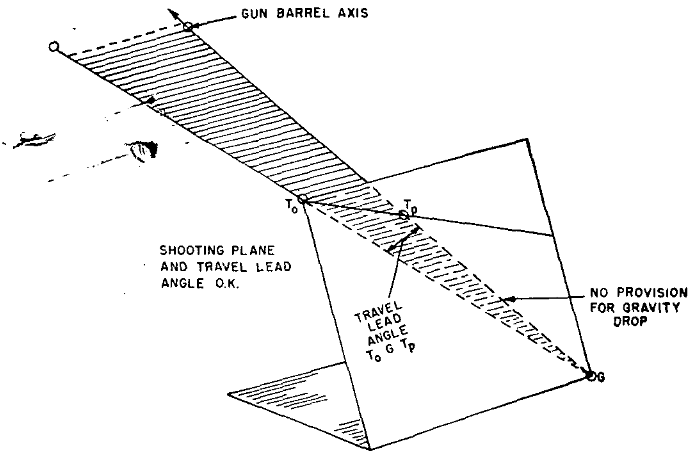

Figure 31. Link III—Lead angle.

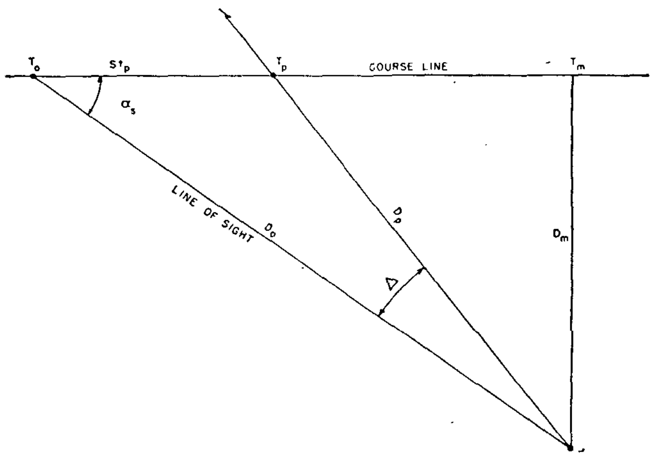

Figure 32. The gunnery triangle.

When Δ_G is equal to Δ_R and all other links of the gunnery chain are established, a hit occurs.

b. The equation to solve for Δ_s in mils is derived by using the law of sines (fig. 32).

$$\frac{\sin \Delta_s}{St_p} = \frac{\sin \alpha_s}{D_p}$$

$$\sin \Delta_s = \frac{St_p \sin \alpha_s}{D_p} = \text{lead equation}$$

c. (1) The tolerance in establishing Link III is the along-course aiming tolerance. The along-course aiming tolerance is one-half the small angle subtended by the length of the target; this tolerance is somewhat greater than the across-course aiming tolerance.

(2) Assuming the lead equation in **b** above to represent the required lead to hit the center of mass of the target (center of mass being a distance of one-half the distance from nose to tail) with the trackers tracking on the center of mass, the distance to the nose of the target measured from T_o is $St_p + \frac{1}{2}L$ (fig. 33).

Therefore—

$$\sin \Delta \frac{N}{R} = \left(\frac{St_p + \frac{1}{2}L}{D_p \textit{ to nose}}\right) \sin \alpha_s$$

The distance to the tail of the target measured from T_o is $St_p - \frac{1}{2}L$. Therefore—

$$\sin \Delta \frac{T}{R} = \left(\frac{St_p - \frac{1}{2}L}{Dp \text{ to tail}}\right) \sin \alpha_s$$

The along-course aiming tolerance becomes—

$$\sin \Delta \frac{N}{R} - \sin \Delta \frac{T}{R} = \left(\frac{St_p + \frac{1}{2}L}{D_p \textit{ to nose}}\right) \sin \alpha_s - \left(\frac{St_p + \frac{1}{2}L}{Dp \text{ to tail}}\right) \sin \alpha_s$$

Considering the aiming point to be the target's center of mass, the actual allowable tolerance becomes one-half of the angle $\Delta \frac{N}{R} - \Delta \frac{T}{R}$

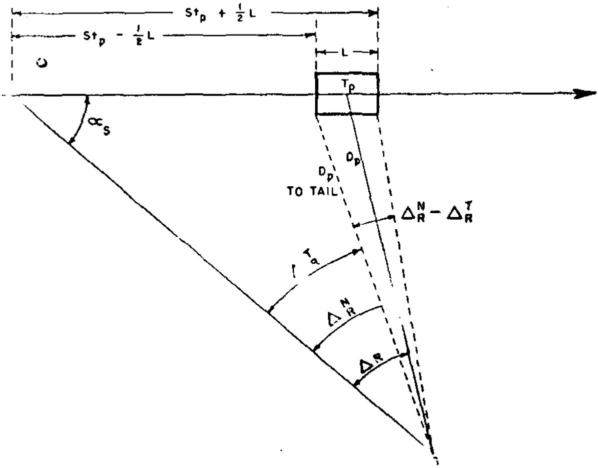

Figure 33. Required lead data.

(3) From a study of the above equation for along-course aiming tolerance, it follows that the tolerance increases as the target length increases. The tolerance also increases as α_s increases to midpoint and

decreases as α_s passes 90° and approaches 180°. Further, the tolerance increases as the range decreases; this condition occurs on the approaching leg of a course. Thus the along-course aiming tolerance is maximum at midpoint. For a sample lead zone, see figure 34.

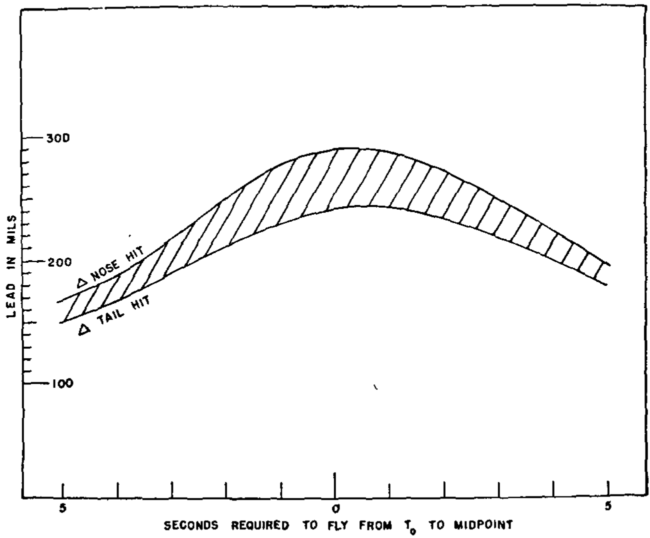

Figure 34. Lead zone.

192. LINK IV — SUPERELEVATION. a. Superelevation is established by the sight mechanism itself during any firing course. For a fixed range superelevation is maximum when angular height is minimum and decreases to zero when angular height equals 90°. This variation of superelevation is caused by gravity acting across the path

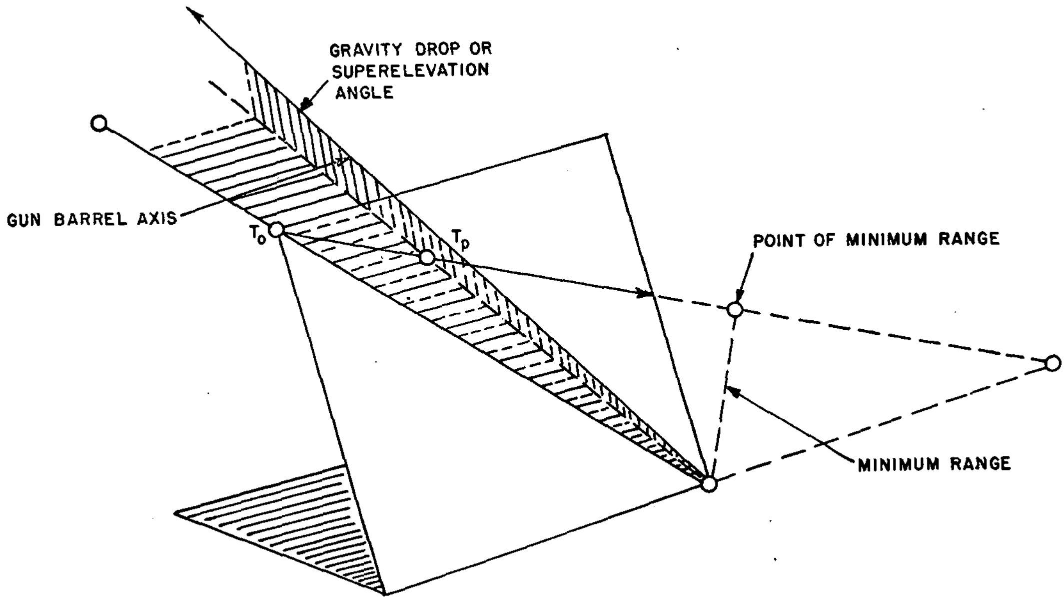

Figure 35. Link IV—Superelevation.

of the projectile at low angular height; whereas at an angular height of 90°, gravity acts along the axis of the gun bore and no compensation for curvature of trajectory is necessary. For a fixed range, superelevation increases as the angular height decreases. For a fixed angular height, superelevation increases as the range increases (fig. 35).

b. For antiaircraft artillery automatic weapons, a superelevation of 9 mils is used as an arbitrary figure; this 9 mils superelevation is used in most automatic weapons siting devices.

CHAPTER 15

ON-CARRIAGE FIRE CONTROL

Section I. GENERAL

193. GENERAL. On-carriage fire control is the process of controlling fire with devices mounted directly on the weapon. The on-carriage sights currently issued use a combination of linear speed of the target along the course line and a function of the direction of the course line in terms of sine α_s as inputs in the lead equation; $\frac{t_p}{D_p}$ is a fixed value. Since on-carriage sights use elements of target course and target speed as data, these sights often are called *Course Speed* devices.

194. TYPES OF ON-CARRIAGE SIGHTS. There are two types of on-carriage fire control devices in use. They are—

a. Computing sights.

b. Speed ring sights.

195. RATE OF FIRE. Present type on-carriage sights depend on fly-throughs to get hits. Since the probability of a hit occurring during the fly-through

depends on the number of rounds intersecting the targets course during the fly-through time interval, it is desirable to fire at the fastest rate compatible with accurate tracking. If it is at all possible, the guns should be fired at automatic fire. When ammunition is restricted for training purposes, the rate of fire is not lowered; automatic fire is used, but only on selected portions of the course. The field of fire is varied so that crews will have practice firing on portions of the approaching leg, a portion around midpoint, and portions of the receding leg.

Section II. COMPUTING SIGHTS

196. GENERAL. Computing sights are designed using the principle of similar triangles (fig. 36). In order to produce a small triangle within the sighting mechanism similar to triangle $GT_o\ T_p$, these sights use a succession of mechanical linkages which place and keep the small triangle $G'T_o'T_p'$ within the slant plane. This method of solving the gunnery problem is the basis for referring to these sights as *slant plane linkage devices.*

197. PRINCIPLES OF CONSTRUCTION. a. The triangle $G'T_o'T_p'$ is at the gun and is reproduced by the sight mechanism (fig. 36). The trackers establish the line of sight or the side $G'T_o'$ of the small triangle. The gun bore, less superelevation, forms the second side ($G'T_p'$) of the triangle. The third side ($T_o'T_p'$) is formed by a lead screw secured to

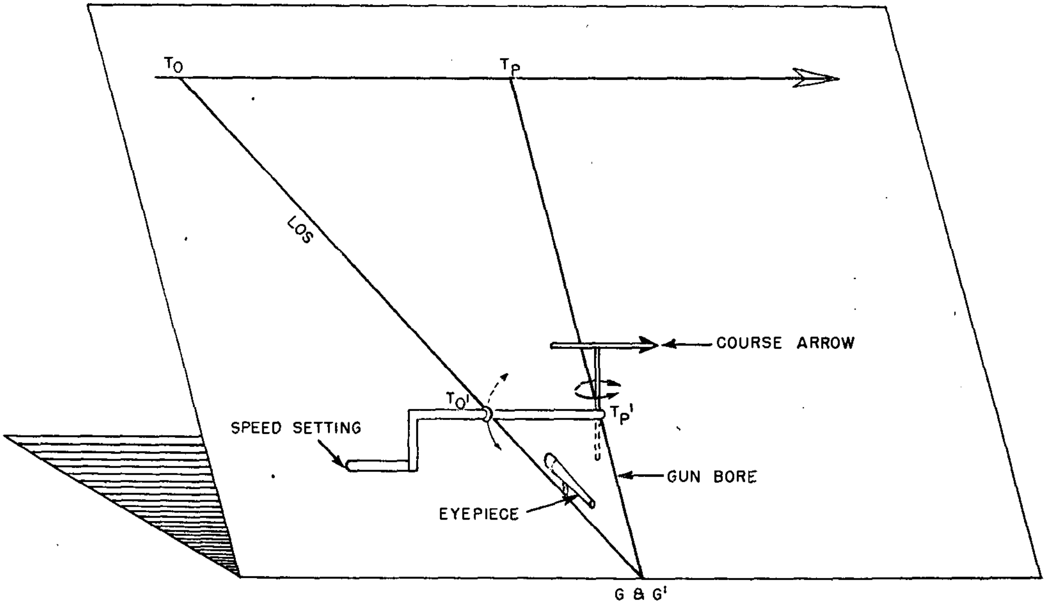

Figure 36. Principles of construction, computing sights.

the vertical axis of the course arrow (at T_p') and mounted in a nut (T_o').

b. The vertical axis of the course arrow moves with the gun bore and is free to rotate; the nut, riding on the lead screw, is anchored to the trackers' sights. The lead screw follows and remains parallel to the course arrow when the arrow is rotated about its vertical axis. By pivoting the course arrow about its vertical axis, the lead screw (third side of the small triangle) can be placed parallel to any level target course line.

c. Two separate adjustments serve to keep the small triangle in the slant plane and similar to the basic triangle (GT_oT_p). They are—

(1) *Slant plane adjustment.* When the course arrow is adjusted to bring the shooting plane in the slant plane, the lead screw follows the course arrow, thus moving the trackers' line of sight vertically and horizontally off the target; the trackers move the line of sight back on the target, thus moving the gun tube the amount the line of sight was displaced.

(2) *Adjustment to keep triangles similar.* When a speed is set in the sight, the lead screw is rotated and the nut mounted on the screw is moved along its $T_o'T_p'$ axis. This movement of the nut moves the line of sight off the target; each tracker, by moving his line of sight back on the target, displaces the gun tube by the amount the line of sight was offset.

d. This adjustable triangle illustrates the principles used in constructing mechanical computing sights.

e. Computing sights are designed with the distance D_p (slant range to future position) equal to 900 yards; this is accomplished in the sighting mechanism by fixing the point T_p' and keeping a fixed distance between G' and T_p'. By adding a few simple mechanisms, the arrow and lead screw remain parallel to a rectilinear course line throughout the course, thus keeping the small triangle in the slant plane by mechanical action.

f. A camming action produces superelevation to complete the gunnery requirements.

g. The above discussion considers level courses only; the solution for nonlevel courses is discussed in paragraph 199.

198. THE GUNNERY CHAIN. a. Link I. Link I is established when the gunpointers place the cross hairs of their sights on the center of mass of the target and continue to track.

b. Link II.

(1) Link II is established when the lead setter positions the course arrow in the proper direction; usually, this is accomplished when the course arrow is made parallel to the target course line. However, the arrow is positioned parallel to the course line only on level courses; nonlevel courses are discussed in paragraph 199.

(2) The course arrow is kept as positioned throughout any course by a gear meshed with the azimuth drive; this gear rotates an equal amount and in an opposite direction from the azimuth drive. The reverse motion of the gear is transmitted through a differential to the course arrow, thus continually repositioning the course arrow to cancel the effect of the traversing motion of the gun tube on the direction of the arrow. For example, if the course arrow were adjusted parallel to a fixed line on the ground and the gun traversed any angular amount, the arrow would remain parallel to the fixed line.

c. Link III. Link III is established when the lead setter adjusts the speed setting until the generated lead angle equals the required lead angle. This is accomplished on level courses when full target speed is set into the sight. However, some type computing sights do not compute for driving or climbing courses; in these cases the triangle $G'T_o'T_p'$ is not similar to triangle GT_oT_p and the lead angle is not solved correctly with full target speed in the sight. Nonlevel courses are discussed in paragraph 199. In all cases, Link III is not satisfied until the generated lead angle equals the required lead angle within aiming tolerance.

d. Link IV. Link IV is initiated when the gun is oriented; with the gun oriented at 0° elevation, the sights are positioned so as to have 9 mils superelevation. As the gun tube is elevated, the superelevation for the changing elevation is solved by

a mechanical action which solves the equation; ϕ_s equals 9 mils multiplied by the cosine of the quadrant elevation (M7A1 and M13 sights) or future angular height (M19 sight). The superelevation varies from 9 mils at zero elevation to 0 mils at 90° elevation. This variance in superelevation is solved by the camming action which rotates the eyepieces of the trackers vertically, thus offsetting the eyepieces from the target. When the tracker brings his eyepiece back on the target he has set in the superelevation for that particular angular elevation.

199. NONLEVEL COURSES. **a.** (1) The course arrow on the M7A1 and the M13 computing sights can be positioned only in the horizontal plane and, therefore, cannot be set parallel to a nonlevel course. However, the course arrow must always lie in the slant plane to establish Link II of the gunnery chain; this is accomplished by pointing the head of the arrow at the ground extension of a diving course line. For climbing courses, the tail of the arrow is pointed at the ground origin of the extended course line (fig. 37). This action places the arrow in the slant plane.

(2) To establish Link III, it is necessary that the generated lead equal the required lead. If full target speed is set into the sight, the generated lead will not equal the required lead because the non-similarity of triangles makes α_s not truly rep-

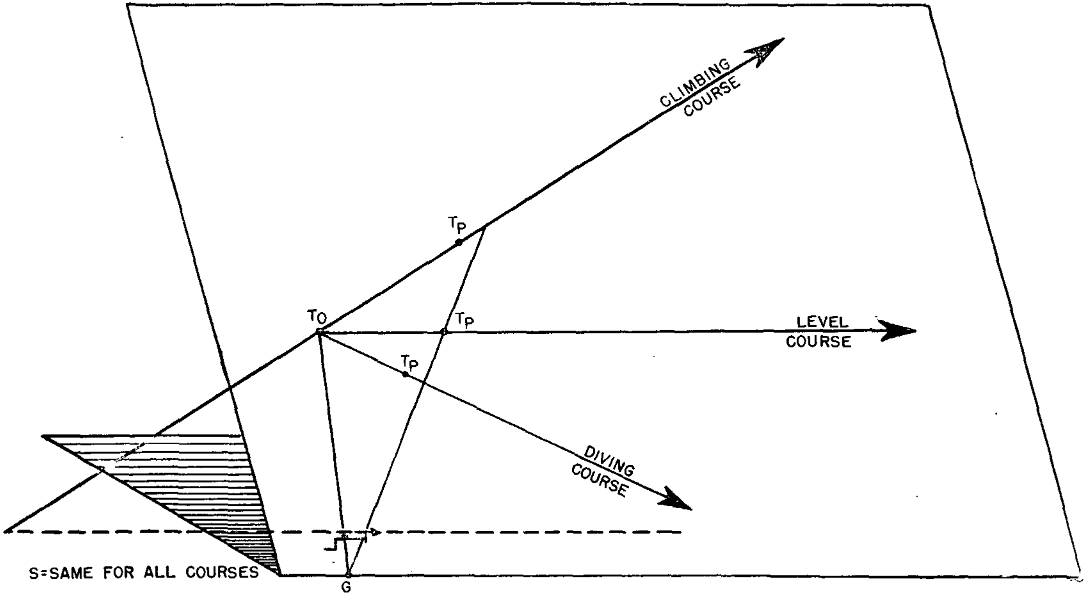

Figure 37. Nonlevel courses, M7A1 and M13 computing sights.

resented in the sight triangle. *Exception*: if the sines of the true α_s and the corresponding angle in the sight triangle are by chance equal, the generated lead will equal the required lead; for example, if α_s equals 85° and the corresponding angle in the sight triangle equals 95°, the numerical value of the sines are equal and Δ_G equals Δ_R. Because of the variation in represented α_s from true α_s, Δ_G is smaller than Δ_R on the approaching leg of a climbing course and larger than Δ_R on the receding leg of a climbing course. On a diving course, Δ_G *is larger than* Δ_R on the approaching leg and smaller than Δ_R on the receding leg (fig. 37). On an average climbing course, firing will take place on the receding leg; on the average diving course, firing will take place on the approaching leg. Therefore, since these sights overcompute for the part of the nonlevel course where firing takes place, it is necessary to put into the sight less than full target speed. The value of this target speed setting is three-fourths full target speed. This speed setting is merely for the initial rounds, and when tracer sensings indicate necessary lead adjustments, the lead setter will follow the rule discussed in paragraph 206**c**.

b. The course arrow on the computing sight M19 can be positioned for dive angles up to 85° and for climb angles up to 60°. Therefore, the arrow

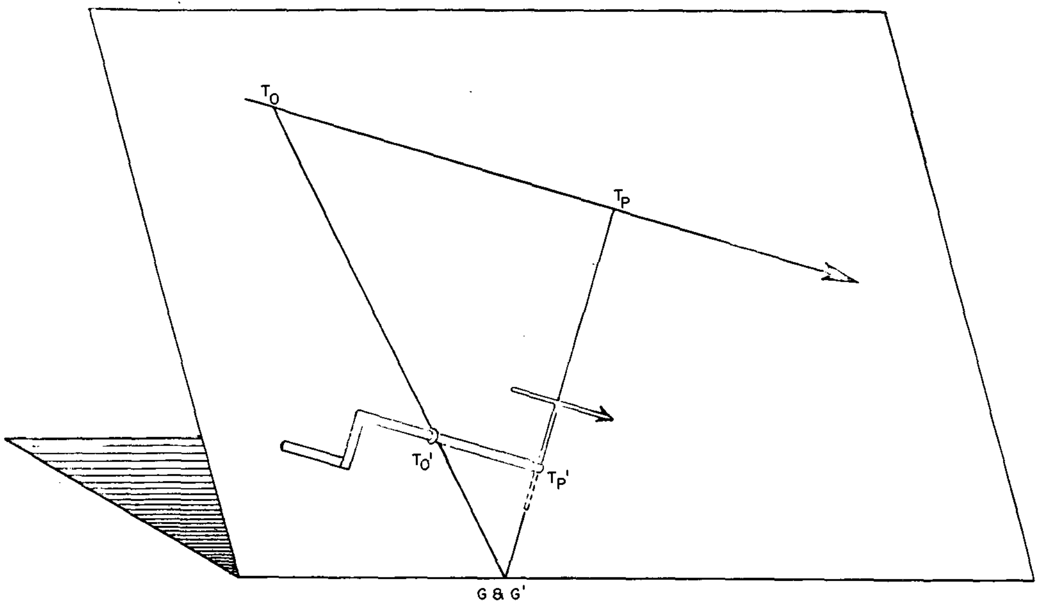

Figure 38. Nonlevel courses, M19 computing sight.

can be placed in the slant plane and alined parallel to nonlevel courses (fig. 38). When the speed setting on the sight equals the target speed, Δ_G equals Δ_R, because α_s is accurately represented in the sight triangle $G'T_o'T_p'$. Therefore, in operating the computing sight M19, the arrow is positioned parallel to the target course line and full target speed is set into the sight for all courses, level or nonlevel.

200. COMPUTING SIGHT M7A1. a. Description. The M7A1 computing sight is mounted on the 40-mm gun on carriage M2A1 as an auxiliary fire control system to the director M5A3 (fig. 39). Its components are a main support bar, a computing box, two M7 telescopes, an azimuth gear box, and a succession of parallel linkages and drives. The parallel linkages keep the computing box level as the gun moves in elevation. The speed dial on the computing box is graduated in 25-mile-per-hour divisions from 0 to 500 miles per hour. Vertical and lateral movement of the trackers' sights is accomplished by a series of rods. The course arrow cannot be made parallel to nonlevel courses.

b. Operation.

(1) *Operation of course arrow.* The lead setter positions the course arrow by turning the course arrow positioning handwheel (fig. 39). This motion passes to a friction clutch in the azimuth gear box where it is algebraically added to a second input coming from the lateral gunpointer who turns the azimuth crank. The output

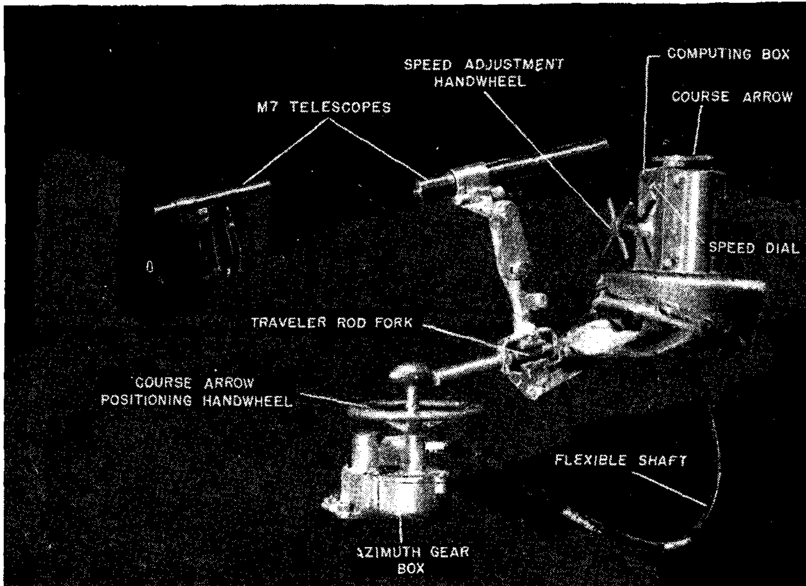

Figure 39. Computing sight M7A1.

from the friction clutch travels along a flexible shaft to the computing box where a series of gears position the course arrow and, at the same time, position the lead screw parallel to the arrow.

(2) *Operation of speed adjusting wheel.* The lead setter sets in speed by turning the speed adjusting wheel on the computing box until the speed dial reads the correct amount. This motion is translated through gears to the lead screw which by turning positions the traveler to represent T_o. T_o' is the pivot of the universal joint under the traveler. T_p is represented by the point where the vertical axis of the lead screw intersects a line through T_o' parallel to the lead screw. G is represented by the traveler rod fork.

c. The computing box.

(1) *Course arrow.* To position the course arrow, the lead setter turns the arrow positioning handwheel (fig. 40). This motion passes to a friction clutch in the azimuth gear box where it is added algebraically to a second input coming from the lateral gunpointer who turns the azimuth crank. The output from the friction clutch travels along a flexible shaft which turns shaft 1 and worm gear 2. Worm gear 2 is meshed to wheel 3 but not to 4. When gear 3 turns it moves gear 4 with it by friction contact. As gear 4 turns it carries with it the lead

screw housing 11 which is fastened to gear 4. The rotation of the lead screw positions the traveler M and the traveler rod N, thus eventually positioning the gunpointers' eyepieces. Gear 4 is meshed to gear 5 thus turning shaft 6, gears 7, 9, and 10, and, finally, the course arrow.

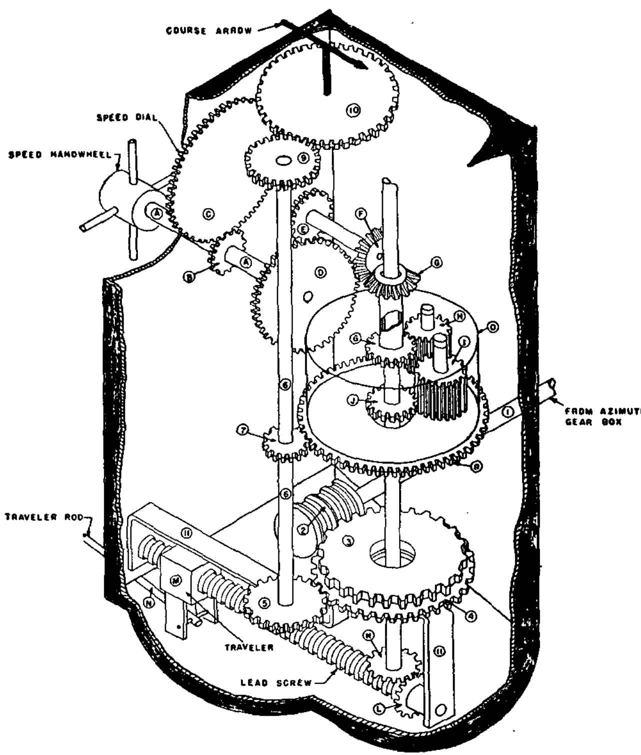

Figure 40. Computing box, M7A1 sight.

(Later models eliminate gear 4, thus having gear 5 mesh directly with gear 3. This prevents the lead setter from grasping the arrow and making slewing adjustments of the arrow's position.)

(2) *Speed adjustment.* When the lead setter turns the speed handwheel, shaft A rotates, and by means of gear B turns the speed dial C to read the speed setting. This motion also rotates gear D which turns gear E and gear F. Gear F turns sleeve G which turns gear H. Gear H turns gear I which turns gear J. Gear J is joined to gear K by a solid shaft; hence, K rotates gear L which turns the lead screw, thus moving the traveler M along the screw. The traveler carries the traveler rod N with it and by the displacement of the traveler rod, the trackers' sights are displaced.

(3) *Differential action.* When the lead screw housing turns about its vertical axis, gear L is displaced with the lead screw. Because gear L is meshed with gear K, this displacement of the lead screw housing must cause gear L or gear K to rotate. But gear L does not rotate; otherwise, the traveler would be repositioned to an incorrect speed setting as the gun traverses or as the lead setter positions the course arrow; therefore, gear K rotates. However, it can be seen that by the gear train mentioned in (2) above, this rota-

tion would cause the speed dial to rotate. The speed dial does not rotate except when speed settings are made. Therefore, to cancel this rotation of gear K there is a differential O in the mechanism. Gear K and gear J turn gear I which rotates gear H. But, as the course arrow and the lead screw turn, gear 7 also turns, thus rotating gear 8 which is a part of differential O. Therefore, differential O moves so that all the rotation of gear H is expended by having gear H walk around sleeve G with sleeve G remaining stationary; hence, no change in speed dial reading.

d. Leveling the computing box.

(1) In order for this computing sight to solve the gunnery problem accurately, the computing box must be level with the mount throughout the entire elevation limits of the gun; there is a tolerance of plus or minus 2 mils in this requirement.

(2) Leveling procedure is as follows:

(*a*) Level the gun mount.

(*b*) Bring the gun tube to 0° elevation.

(*c*) Extend the length of the computing box by placing a flat steel bar across the milled surfaces of the box. With the gunners quadrant set at zero, place it on the flat steel bar. Record any deviation of the bubble from 0 mils.

(*d*) Elevate the gun to 15°, 30°, 45°, 60°, and 75°, in turn, and record the readings on the gunners quadrant at each test position. Make all test readings by approaching the test positions from the same direction in order to eliminate backlash errors.

(*e*) If the deviation from zero exceeds plus or minus 2 mils, elevate the gun to the position that gave the greatest error and turn the parallel linkage rod turnbuckle until the bubble is centered.

(*f*) Repeat step (*d*).

(*g*) If the deviation from zero exceeds plus or minus 2 mils, elevate the gun to the position that gave the greatest error and take out one-half of the amount of the error by adjusting the eccentric at the sight bracket end of the parallel linkage rod. Then take out the remaining half of the error by turning the parallel linkage rod turnbuckle.

(*h*) Repeat steps (*f*) and (*g*) until the deviation remains within tolerance.

e. Orientation.

(1) Set the speed dial at zero.

(2) Boresight the gun on a distant orienting point by elevating and traversing.

(3) Remove the sight bracket retaining pin and tip the computing box forward as far as it will go.

(4) Check the gunpointers' telescopes for alinement on the orienting point.

(5) Adjust the M7 telescopes laterally by loosening the locking bolt at the base of the telescope support bracket. Turn the telescopes on the orienting point. Tighten the locking bracket.

(6) Adjust the M7 telescopes vertically by loosening the locking bolt on the telescope support arm. Turn the telescopes vertically to get on the orienting point. Tighten the locking bolt.

(7) Tip the computing box back to its upright position and replace the sight bracket retaining pin.

f. Superelevation. The origin of superelevation in the computing sight M7A1 is a cam (fig. 41). With the gun at 0° elevation, the cam is at its minimum position and the computing box has dropped its maximum distance. This offset distance subtends 9 mils measured as the angle T_p' to the traveler rod yoke, to the intersection of the vertical axis of the lead and a line from the traveler rod yoke parallel to the axis of the gun bore. As the gun elevates, the parallel linkage rod causes the computing box to remain level, thus rotating the superelevation cam. As the cam rotates, the collar from the superelevation link assembly restricts the lateral movement of the cam while permitting the vertical motion of lifting the computing box to take place. Because a lateral motion must take place to prevent jamming, the axle of

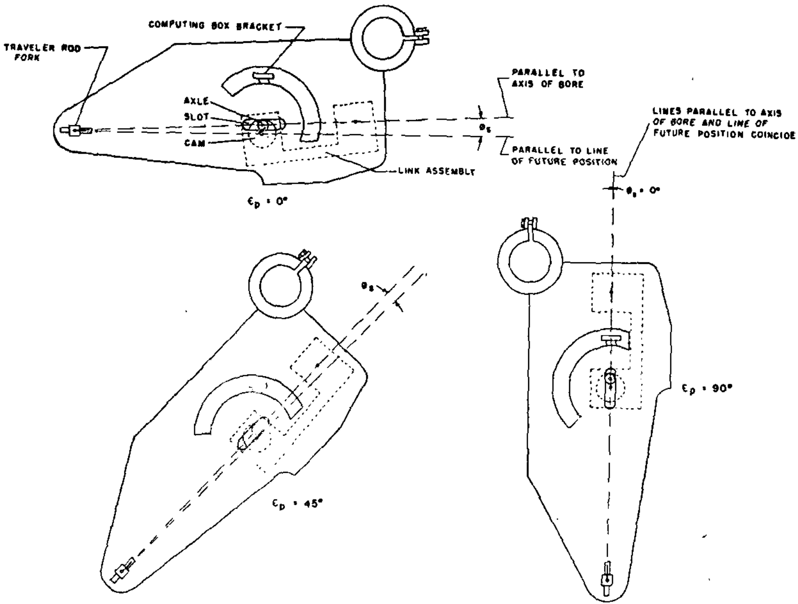

Figure 41. Superelevation mechanism, M7A1 sight.

the cam slides laterally in the slot on the main support bracket. As a result, the computing box rises but, for all practical purposes, does not move laterally; this motion keeps the sight representation of D_p constant. This vertical motion by the computing box raises the traveler which, through the traveler rod and connected rods, raises the gunpointers' sights and takes out superelevation in proportion to the changes in cosine of ϕ. With the gun bore at 90° elevation, the cam is at its maximum position and the computing box has raised until the offset distance is zero; at this elevation the angle from T_p' to the traveler rod fork, to the intersection of the vertical axis of the lead screw and a line from the traveler rod yoke parallel to the axis of the gun bore is zero and no superelevation is established.

201. COMPUTING SIGHT M13. a. Description. The computing sight M13 is mounted on the twin 40-mm gun motor carriage M19 as the primary system of fire control (fig. 42). Its components are a main support bar, a computing box, one reflex sight M23, one reflex sight M24, an auxiliary control box, and a succession of parallel linkages and drives. The parallel linkages keep the computing box level as the gun moves in elevation. The speed dial on the computing box is graduated in 25-mile-per-hour divisions from 0 to 500 miles per hour. Vertical and lateral movement of the trackers' sights is accomplished by a series of rods. The course arrow cannot be made parallel to nonlevel courses.

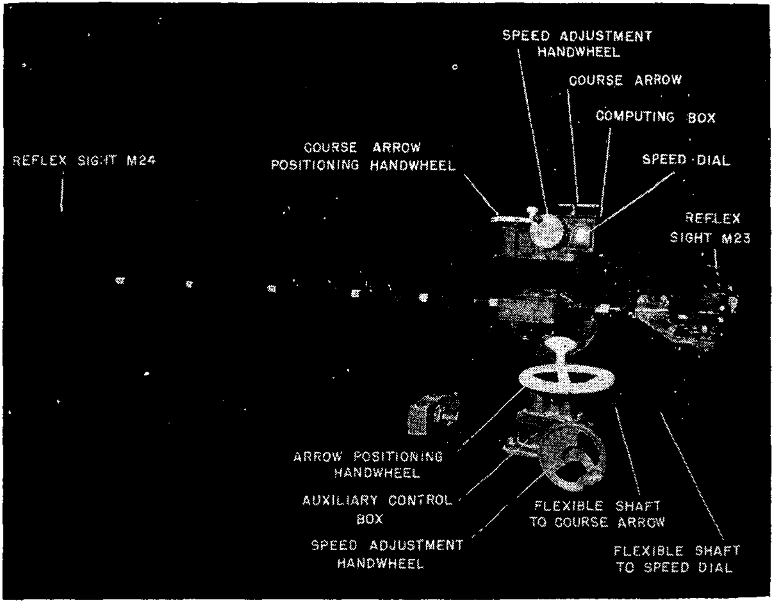

Figure 42. Computing sight M13.

b. Operation.

(1) *Operation of course arrow.* The lead setter can position the course arrow from one of two sources; one at the auxiliary control box, the other at the computing box (fig. 42). By turning the arrow positioning handwheel on the auxiliary control box, a motion is imparted to a differential in the auxiliary control box. A second input to the differential comes from the azimuth tracking mechanism on the gun. These two inputs are added algebraically and the output passes along the flexible shaft to the computing box and another differential. The second input to this differential comes from the arrow positioning handwheel on the computing box. This input will be zero since the arrow is being positioned at the auxiliary control box. The output from this differential then is actually the output from the auxiliary control box differential. When the arrow positioning handwheel on the computing box is used, the input from the arrow positioning handwheel on the auxiliary control box is zero; therefore, the output of the auxiliary control box differential is data from the azimuth tracking mechanism. This output follows the flexible shaft to the computing box differential where it is added algebraically to the input from the computing box arrow positioning hand-

wheel. Regardless of the source of arrow positioning, the output of the computing box differential positions the lead screw and at the same time positions the course arrow parallel to the lead screw.

(2) *Operation of the speed adjustment handwheel.* The lead setter can set in speed from one of two sources; one at the auxiliary control box, the other at the computing box. By turning the speed handwheel on the auxiliary control box, a motion is imparted through the flexible shaft to the computing box where, by gear train, the motion turns the speed handwheel on the computing box until the speed dial reads the correct amount. This motion also turns the lead screw which positions the traveler to represent T_o. T_o' is the pivot of the universal joint under the traveler. If the lead setter turns the speed handwheel on the computing box, the gear train will turn the speed dial, the lead screw, and by the flexible shaft the speed handwheel on the auxiliary control box. T_p is represented by the point where the course arrow shaft intersects a line through T_o' parallel to the lead screw. G is represented by the traveler rod yoke.

c. Computing box.

(1) *Course arrow.* To position the course arrow, the lead setter turns the arrow positioning handwheel (fig. 43), which

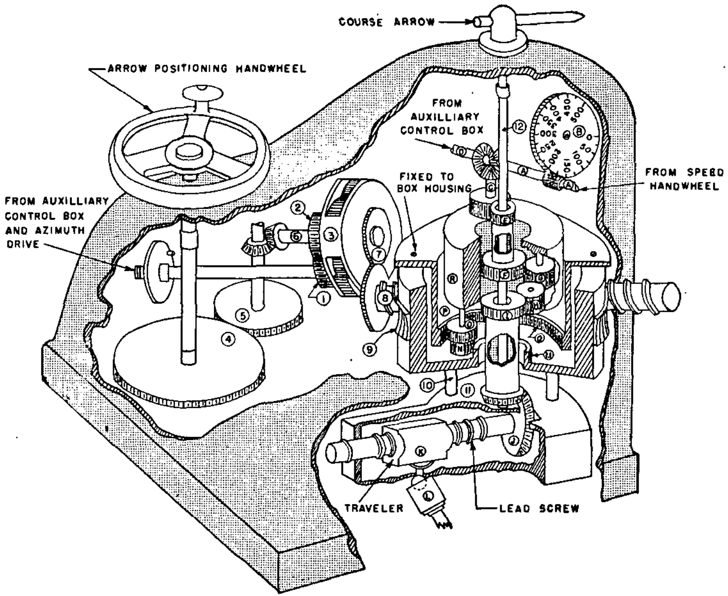

Figure 43. Computing box, M13 sight.

by gear 4 turns gear 5 which sends an input to differential 3 through shaft 6. A second input to the differential comes from the flexible shaft which turns gear 1 sending the input through gear 2. The output from the differential turns gear 7 which rotates the worm gear 8 which, by meshing with the wheel gear 9, positions the housing. The motion of the housing carries the lead screw housing 11 with it by means of the pins 10. The rotation of the lead screw positions the traveler K and the traveler rod L, thus eventually positioning the gunpointers' eyepieces. The rotation of the lead screw also turns the arrow shaft 12 which is firmly joined to the lead screw housing 11. The arrow shaft then positions the course arrow.

(2) *Speed adjustment.* When the lead setter turns the speed handwheel, shaft A rotates and turns the speed dial B to read the speed setting. This motion also rotates shaft C, thereby causing shaft D to rotate and the speed handwheel on the auxiliary control box to turn. If the lead setter had turned the speed handwheel on the auxiliary control box initially, the motion would have passed over the same series of shafts mentioned above and finally would have caused the speed handwheel on the computing box to turn. The rotation of shaft C turns gears E and F which pivot freely by a sleeve fitting

around the course arrow shaft 12. Gear F turns gear G which through gear H rotates sleeve I. This rotation passes to the bevel gear J which turns the lead screw, thus moving the traveler K along the screw. The traveler carries the traveler rod L with it and by the displacement of the traveler rod, the trackers' sights are displaced.

(3) *Differential action.* When the lead screw housing turns about its vertical axis, the bevel gear J is displaced with the lead screw. Because gear J is meshed with the bevel gear of sleeve I, this displacement of the lead screw housing must cause gear J or sleeve I to rotate. But gear J does not rotate; otherwise, the traveler would be repositioned to an incorrect speed setting as the gun traverses or as the lead setter positions the course arrow. Therefore, sleeve I rotates. However, it can be seen that by the gear train mentioned in (2) above, this rotation would cause the speed dial to rotate. The speed dial does not rotate except when speed settings are made. Therefore, to cancel this rotation of sleeve I, there is a differential R in the mechanism. Sleeve I turns gear H which turns gear G. At the same time that worm gear 8 positions the housing by means of the wheel gear 9, gear M rotates with the housing. Gear M turns gears N and O

which are rigidly joined. Gear O is meshed to wheel Q. Wheel Q is fixed to the computing box housing through its mounting P. Therefore, when gear O rotates, it walks around wheel Q, thus moving the differential R so that all the rotation of gear G is expended by having gear G walk around gear F with gears F and E remaining stationary; hence, no change in speed dial reading.

d. Leveling the computing box.

(1) In order for the computing sight M13 to solve the gunnery problem accurately, the computing box must stay level with the mount throughout the elevation limits of the gun. There is a tolerance in this level of plus or minus 2 mils.

(2) Leveling procedure is as follows:

(*a*) Place a gunner's quadrant on the quadrant seat on the gun trunnion. Record the reading with the bubble level; this reading is zero if the mount is on level ground.

(*b*) Place a gunner's quadrant on the quadrant seat on the breech casing. Adjust the gun in elevation until the quadrant reading is the same as in step (*a*) above.

(*c*) Without changing the reading recorded in step (*a*), place the gunner's quadrant on the quadrant seat on the

computing box. Record any deviation of the bubble from the recorded reading of step (*a*).

(*d*) Elevate the gun to 15°, 30°, 45°, 60°, and 75°, in turn, and record the gunner's quadrant reading at each test position. Approach the test position from the same direction in order to eliminate backlash errors.

(*e*) If the deviation from the reading of step (*a*) exceeds plus or minus 2 mils, elevate the gun to the position which gave the greatest error and turn the parallel linkage rod turnbuckle until the bubble is centered.

(*f*) Repeat step (*d*).

(*g*) If the deviation from the reading in step (*a*) exceeds plus or minus 2 mils, elevate the gun to the position that gave the greatest error and take out one-half the amount of the error by loosening the flange nut and locking screw (trunnion end of parallel linkage) and turning the flange itself. Tighten the flange nut and locking screw. Then take out the other half of the error by turning the parallel linkage rod turnbuckle.

(*h*) Repeat steps (*f*) and (*g*) until the deviation remains within tolerance.

e. Orientation.

(1) Set the speed dial to zero.

(2) Boresight the gun on a distant orienting point by elevating and traversing.

(3) Remove the sight bracket retaining pin and tip the computing box forward as far as it will go.

(4) Check gunpointers' sights for alinement on the orienting point.

(5) Adjust the reflex sight M23 laterally by turning the adjusting screws in rear of sight support until the vertical line lies on the orienting point.

(6) Adjust the reflex sight M24 laterally as in step (5). Adjust vertically by loosening the lock screw in the eccentric in front of the sight and then with a screwdriver turn the eccentric until the main cross hairs lie on the orienting point. Tighten the lock screw.

(7) Tip the computing box into its upright position and replace the sight bracket retaining pin.

f. Superelevation. The origin of superelevation in the computing sight M13 is a cam (fig. 44). With the gun bore at 0° elevation, the cam is at its minimum position and the computing box has dropped its maximum distance. This offset distance subtends 9 mils measured as the angle from T_p' to the traveler rod yoke, to the intersection of the course arrow shaft and a line from the traveler rod yoke parallel to the axis of the gun bore. As the gun elevates, the parallel linkage rod causes the computing box to remain level, thus causing

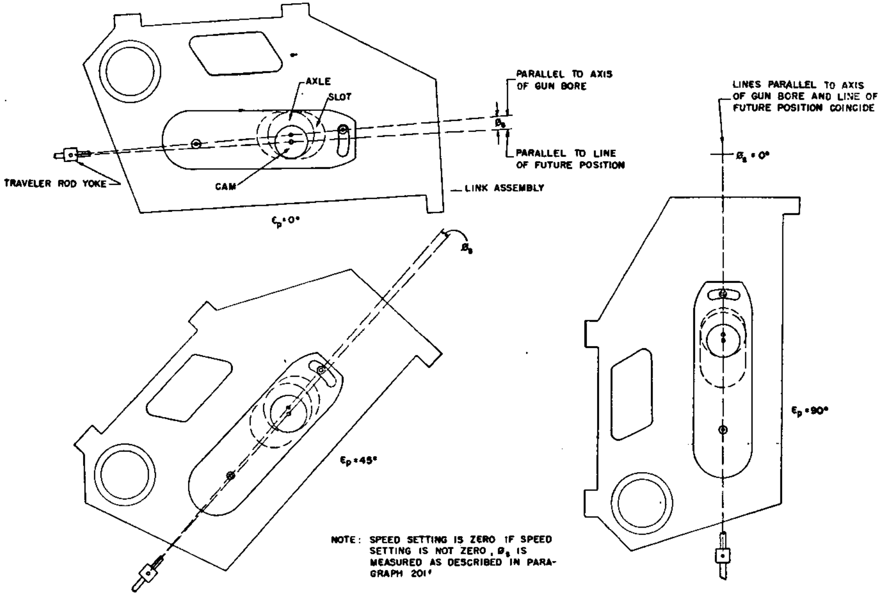

Figure 44. Superelevation mechanism, M13 sight.

a rotation of the superelevation cam. As the cam rotates, the collar from the superelevation link assembly restricts the lateral movement of the cam while permitting the vertical motion of lifting the computing box to take place. Because a lateral motion must take place to prevent jamming, the axle of the cam slides laterally in the slot on the main support bracket. As a result, the computing box rises but, for all practical purposes, does not move laterally; thus the sight representation of D_p is kept constant. This vertical motion by the computing box raises the traveler which through the traveler rod and connected rods raises the gunpointers' sights, thus taking out superelevation in proportion to the changes in the cosine of ϕ. With the gun bore at 90° elevation, the cam is at its maximum position and the computing box has raised until the offset distance is zero; at this elevation, the angle from T_p' to the traveler rod yoke, to the intersection of the course arrow shaft and a line from the traveler rod yoke parallel to the gun bore is zero and no superelevation is established.

202. COMPUTING SIGHT M19. a. Description. The computing sight M19 is mounted on the 40-mm gun on the carriage M2A1 as the secondary fire control system (fig. 45). Its components are a main support bar, a computing box, one reflex sight M23, one reflex sight M24, an azimuth gear box, a steel band for transmitting lateral motion to the gunpointers' sights, a rod and pivot for elevation drive to the sights, and a parallel linkage for

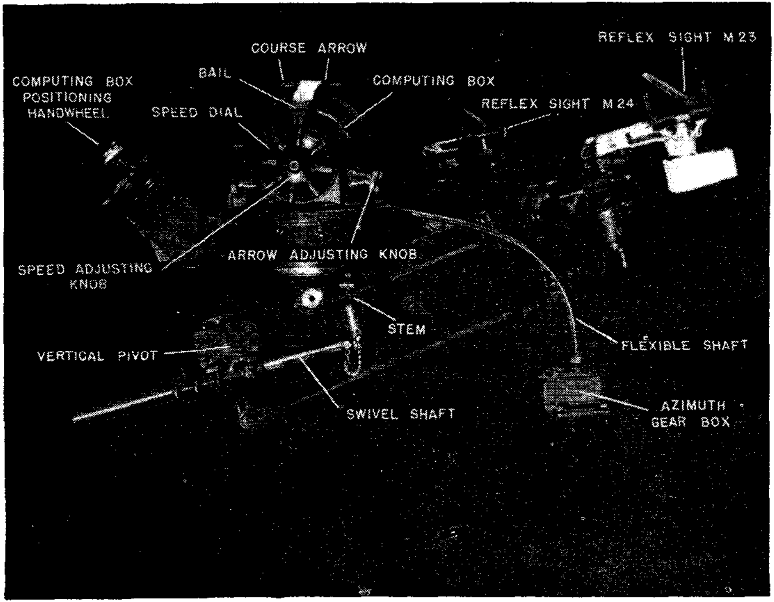

Figure 45. Computing sight M19.

keeping the computing box level as the gun moves in elevation. The speed dials on the computing box are graduated in 20-mile-per-hour divisions from 0 to 700 miles per hour. The course arrow can be positioned for dive angles up to 85° and for climb angles up to 60°.

b. Operation.

(1) *Operation of course arrow.*

(*a*) The lead setter positions the course arrow for diving courses by means of the bail, or for fine adjustments he turns one or both of two arrow adjusting knobs on the computing box (fig. 45). This motion passes to a hub which is keyed to the lead râck housing, thus rotating the lead rack parallel to the course arrow. The two arrow adjusting knobs are geared to the hub and turn as the hub turns, or by the same gearing, if the motion originates at the knobs, they turn the hub and thus position the course arrow and lead rack. In order to prevent a change in speed setting during a change in arrow angle of dive or climb, the entire speed mechanism rotates with the course arrow.

(*b*) To position the arrow horizontally, the lead setter turns the computing box positioning handwheel. This motion passes to a differential. The second input into the differential is introduced

when the lateral gun pointer turns the azimuth hand crank. This motion is carried through the azimuth gear box along a flexible cable to the differential. These two inputs are added algebraically and the output motion turns a series of gears which move the entire computing box except the base. When the computing box turns, it positions the arrow and lead rack parallel to the target course line horizontally.

(2) *Speed adjustment.* The lead setter sets in speed by turning one or both speed knobs until the dials read the correct amount. This motion is translated by a keyed shaft and a gear to the lead rack which positions the stem ball to represent T_o. T_p is represented by the point of intersection of the vertical axis of the computing box with a line passing through the stem ball parallel to the lead rack. G is represented by the vertical pivot of the swivel shaft.

c. Computing box.

(1) *Course arrow.*

(*a*) *Horizontal adjustment.* When the lead setter turns the computing box positioning handwheel, gear 1 rotates and supplies one input to the differential (fig. 46). The second input comes from the azimuth gear mechanism along the flexible shaft to worm gear 2

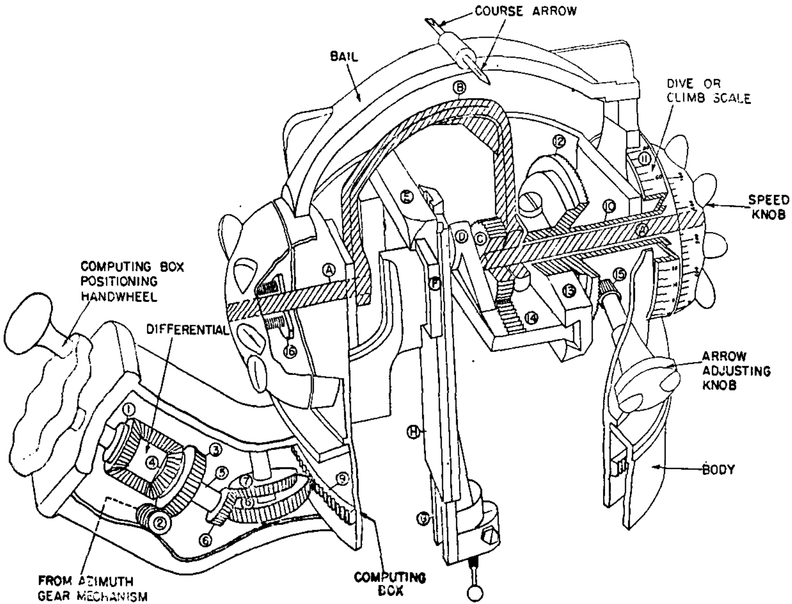

Figure 46. Computing box, M19 sight.

which turns gear 3 which, by direct connection, turns gear 4. The two inputs are added algebraically and the single output turns shaft 5 which by turning gear 6 rotates gear 7 which, by direct connection, turns gear 8. Gear 8 is meshed to the computing box azimuth base ring gear 9; hence, gear 9 turns and moves the entire computing box less the body, thus positioning the course arrow and the lead rack horizontally.

(*b*) *Dive or climb adjustment.* For course adjustment, the lead setter grasps the bail and positions the course arrow. The rotation of the bail turns the climb or dive scales 11 and the hub 10 which by direct connection turns gear 12 and lead rack guide 13 thus positioning the lead rack 14 approximately parallel to the target course. For fine adjustment, the lead setter turns the arrow adjusting knobs which rotate gear 15 thus turning gear 12 which, by direct connections through hub 10, turns scales 11 to read the adjusted angle of dive, and also rotates lead rack guide 13 thus positioning the lead rack 14 parallel to the target course.

(2) *Speed.* When the lead setter turns the speed knobs, he turns shafts A which are connected by yoke B. This rotation turns gear C which moves the lead rack 14

along the guide 13, thus positioning the lead rack pivot D. The movement of pivot D is converted to lateral and vertical components. The lateral component causes movement of guide E along slide F, thus moving guide H which positions the stem ball laterally. The vertical component causes movement of the stem G along guide H, thus positioning the stem ball vertically.

(3) *Differential action.* As the lead setter positions the lead rack for climb or dive angles, the lead rack 14 would walk around gear C if gear C were stationary. The result would be a new speed setting on the speed knobs and, of course, the lead rack pivot D would have changed position to an erroneous setting. This condition must not occur; therefore, a differential action takes place. The lead rack 14 revolves as a result of a vertical movement of the bail. Between each speed knob and the bail there is a friction pad 16 keyed to the knob and forced against the bail by springs. Therefore, when the bail moves vertically, the speed knobs move with the bail because the friction of the pad is greater than the inertia of the knobs, gear C, and lead rack 14. Thus, gear C and rack 14 remain meshed without change, and speed readings on the knobs remain unchanged. When the lead setter turns the speed knob

to change the speed setting, the friction of the pad is not great enough to overcome the inertia of the arrow positioning mechanism and so the pad rotates with the knob but the bail remains stationary, thus no change in arrow position occurs.

d. Leveling the computing box.

(1) In order for the sight to solve the gunnery problem accurately, the computing box must stay level with the mount throughout the elevation limits of the mount; a tolerance of plus or minus 1 mil is allowed at this level requirement. The computing box will require leveling at various times.

(2) Leveling procedure is as follows:

(*a*) Level the gun mount.

(*b*) Bring the gun tube to 0° elevation.

(*c*) Place a gunner's quadrant set to 0 mils on the quadrant seat of the sight bracket. If the deviation from zero exceeds plus or minus 1 mil, adjust the parallel link rod turnbuckle until the bubble is centered.

(*d*) Elevate the gun to 90° and again place the gunner's quadrant on the quadrant seat. If the deviation exceeds plus or minus 1 mil, center the bubble by placing shims under the bracket for the parallel link (on the gun trunnion).

(*e*) Repeat steps (*c*) and (*d*) until the deviation remains within tolerance.

(e) Elevate the gun to 15°, 30°, 45°, 60°, and 75°, in turn, and record the readings of the gunner's quadrant at each check position. Approach the check positions from the same direction in order to eliminate backlash. If the deviation from zero exceeds plus or minus 1 mil at any elevation, repeat steps (*c*) and (*d*) until the deviation at any elevation remains within tolerance.

e. Orientation.

(1) Set the speed dial to the position marked BS.

(2) Set the course arrow parallel to the axis of the gun bore with the head of the arrow pointed toward the breech end of the gun.

(3) Place course arrow at dive angle of 85°.

(4) Boresight the gun on a distant orienting point by elevating and traversing.

(5) Check the gunpointers' sights for alinement on the orienting point.

(6) Adjust both gunpointers' sights in azimuth by turning the screw of the worm gear in the reflex sight support cap; an adjustment of 360° is possible.

(7) Adjust both gunpointers' sights in elevation by loosening the clamp screw located on each sight support housing. Then turn the screw of the worm gear located above the clamp screw on each housing.

A worm gear moves along a gear rack to produce a vertical motion. An adjustment of 360° is not possible. When sights are adjusted vertically, tighten the clamp screws.

(8) Return the course arrow and speed dial to standby setting.

(9) The above procedure assumes the stem ball to be offset the proper distance, subtending 9 mils measured from the vertical pivot of the swivel shaft with the gun bore at 0° elevation. To check or adjust this distance observe the following procedure:

(*a*) Level the gun mount.

(*b*) Level the gun tube and the computing box.

(*c*) With speed set at zero, place a gunner's quadrant on a bar across the level pads of the output assembly; the gunner's quadrant is set at minus 9 mils.

(*d*) Remove the protective bag at the base of the computer, loosen the clamp screw on the base of the slide, and unscrew the stem until the bubble of the quadrant (set at minus 9 mils) is centered.

(*e*) Tighten the clamp screw.

(*f*) Replace the protective bag.

(*g*) The above procedure should be executed periodically to assure the correct stem ball offset distance; however, it need not be done each time the weapon is oriented.

f. Superelevation. The origin of superelevation in the computing sight M19 is the offset distance of the stem ball below the computer support trunnion axis (fig. 47). This offset distance subtends the angle formed by the line $G'T_p'$ and a line passing through the vertical pivot of the swivel shaft and parallel to the axis of the gun bore; the offset distance is perpendicular to the line passing through the pivot of the swivel shaft and parallel to the axis of the gun bore. At 0° elevation, this offset distance subtends 9 mils. As the gun elevates, the parallel linkage rod causes the computing box to remain level, thus causing a relative rotation of the stem ball. As the stem ball rotates about the computer support trunnion axis, the offset distance becomes less and, as a result, the angle it subtends becomes less. This angle is superelevation which decreases in proportion to changes in the cosine of ε_p. (Differs from M7A1 and M13 sights by construction.) With the gun bore at 90° elevation, the offset distance just mentioned becomes zero, and hence the superelevation angle is zero mils. In orientation when the lead setter places the course arrow toward the breech of the gun and sets the speed dial to read BS, he moves the lead rack, which of course moves the stem ball, up along a line 85° from the horizontal. This computing box setting causes the gunpointers' sights to elevate 9 mils and places T_o' on the line from the vertical pivot of the swivel shaft parallel to the axis of the gun bore. This action takes out superelevation during orientation.

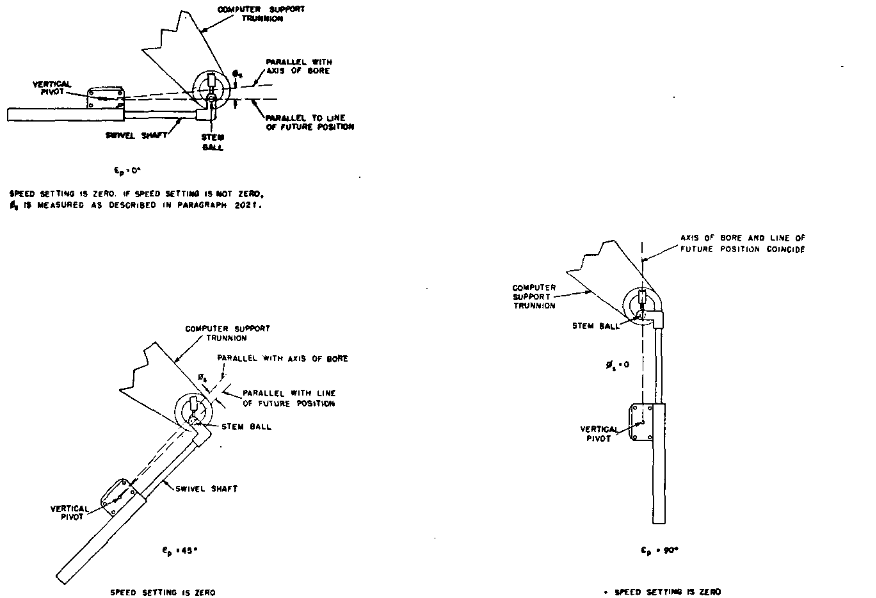

Figure 47. Superelevation mechanism, M19 sight.

203. REFLEX SIGHT M24. a. Description. The M24 sight is the basic sight for the vertical gunpointer on weapons equipped with the computing sights M13 and M19. The sight projects a sharp image of a reticle into the field of view of the gunpointer. The gunpointer looks through a sloping glass plate coated to produce a mirror effect in addition to being a window. By looking through this sloping glass plate, the gunpointer sees the actual target through the glass and also the reflection of the sight reticle on the glass. Both the target and the image of the reticle appear at the same range. During daylight hours, the sight is illuminated by sunlight; for operation during periods of reduced visibility, the sight is illuminated with an electric light.

b. Operation

(1) The light rays from the sun enter the sight directly through the window and by reflection from the prism above the window (fig. 48). These rays are bent 90° by the prism below the window and are passed through the reticle to the mirror where they are again bent 90° and pass to the lens. The lens magnifies the image of the reticle which now passes to the reflector and is reflected to the gunpointer's eye. As in any mirror, the image appears inside the reflector. Because of the magnification, the image of the reticle always subtends the same angle regardless of range. For example, at

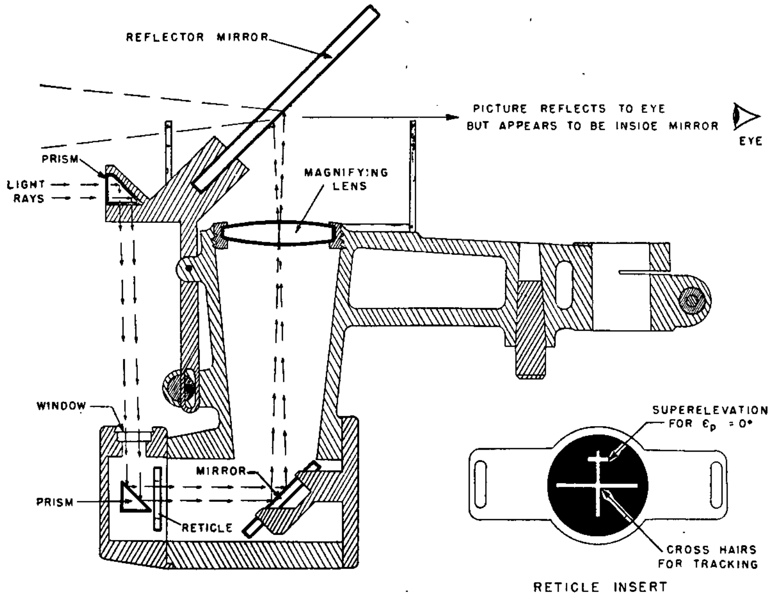

Figure 48. *Reflex sight M24 (graphical presentation only).*

100 yards the image of the reticle will appear a certain size against a target, at that range; with a target at 1,000 yards, the image will appear to be 10 times larger, though still subtending the same angle.

(2) When the gunpointer tracks he sees the target through the reflector. At the same time, because of the mirror effect of the reflector, he sees the image of the reticle appearing out in space. He then moves his sight until the image of the main cross hairs intersect at the center of mass of the target.

c. Reticle. The reticle of the M24 sight has two intersections of cross hairs (fig. 48). The lower intersection is the main intersection and is used for tracking. When it is on the center of mass of the target, the axis of the gun bore is above the line of sight by the amount of superelevation corresponding to that elevation. The upper intersection is the superelevation indicator and is used to make hasty checks of superelevation; the gun tube must be at 0° elevation for this check. To make this check, the gun tube must be placed on an orientation point at 0° elevation; the superelevation cross hair then should fall on the orienting point. If the orienting point is at an elevation other than 0°, an error will result.

d. Adjustments.

(1) The M24 sight is adjusted in elevation by loosening the lock screws in the ec-

centric in front of the sight and then with a screwdriver turning the eccentric. The eccentric turns the arm from the upper prism bracket which rotates the reflector. This rotation changes the angle of refraction of the light rays from the magnifying lens, thus raising or lowering the image of the reticle with respect to the gunpointer's eye.

(2) The method of adjustment in azimuth depends upon the type sight bracket and has been explained in the previous paragraphs on orientation of the various sights.

204. REFLEX SIGHT M23. a. Description. The M23 sight is the basic sight for the lateral gunpointer on weapons equipped with the computing sights M13 and M19. The sight projects a sharp image of a reticle into the field of view of the gunpointer. The gunpointer looks through a sloping glass plate coated to produce a mirror effect in addition to being a window. The gunpointer sees the actual target through the glass and also sees the reflection of the sight reticle on the glass. Both the target and the image of the reticle appear at the same range. During daylight hours, sunlight illuminates the sight reticle; during the hours of reduced visibility, an electric light is placed over the window for illumination.

b. Operation. The light rays from the sun enter directly through the window and by reflection from the prism above the window (fig. 49). These

rays are bent 90° by a mirror below the window and are again bent 90° by a prism set vertically. The light then passes through the reticle to the mirror where the rays are again bent 90° and pass to the lens. The lens magnifies the image of the reticle which now passes to the reflector and is reflected to the gunpointer's eye. As in any mirror, the image appears inside the reflector. Because of the magnification, the image of the reticle always subtends the same angle, regardless of range. When the gunpointer tracks, he sees the target through the reflector. At the same time, because of the mirror effect, he sees the image of the ret-

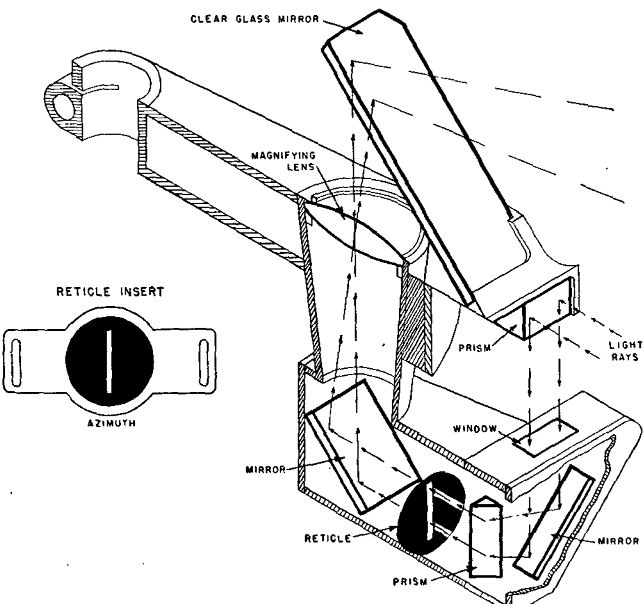

Figure 49. Reflex sight M23 (graphical presentation only).

icle appearing out in space. He then moves his sight until the image of the vertical line intersects the center of mass of the target.

c. Reticle. The reticle of the M23 sight consists of one vertical line (fig. 49).

d. Adjustment. The method of adjusting the M23 sight laterally and vertically depends upon the type of sight bracket and has been explained in previous paragraphs on orientation of various sights.

205. M7 TELESCOPES. The M7 telescopes are single-power telescopes in which one cross hair is broken at the center and one is unbroken. The elevation telescope is installed with the unbroken cross hair horizontal; the azimuth telescope is installed with the unbroken cross hair vertical.

206. FIRE ADJUSTMENT WITH COMPUTING SIGHTS.
a. Operational firing.

(1) Because of the high speed and short courses offered by combat targets, it rarely is possible to make speed setting adjustments. Since the lead setter must first secure line shots before attempting lead adjustment, most combat target courses will be completed before the lead setter has an opportunity to adjust speed. This apparent limitation of the sight is overcome by setting in standby speeds before targets are engaged. This standby speed is determined by intelli-

gence reports on the type of enemy aircraft operating in a particular area.

(2) When the lead setter first sees an enemy aircraft, he sets in the sight an estimated speed; this estimated speed may or may not be the standby speed. After setting in speed, the lead setter positions the course arrow parallel to the course for level courses and according to the rules previously given for non-level courses. When the target is within range, the guns are fired. During firing, the lead setter adjusts for line shots and, if time is available and the need exists, he adjusts for speed.

(3) In certain situations it may be advisable to assign a spread of standby speeds to the weapons defending an objective, and depend upon variations in the ranges from the several guns to the target to produce hits. A gun with insufficient speed set into its computing sight might get a hit because of extremely short range; a gun with too much speed set in the sight might also get a hit because of extremely long range. For any one target flying over an objective, there will be a spread of ranges as numerous as there are guns; hence, it is possible by different speed settings on different guns to depend upon the variety in ranges to produce fly-throughs for a percentage of the guns. An example of this system for

an eight-gun pattern and expected target speed of 350 miles per hour would be:

2 guns—target speed 325 miles per hour.
2 guns—target speed 350 miles per hour.
2 guns—target speed 375 miles per hour.
2 guns—target speed 400 miles per hour.

b. Line adjustment.

(1) The lead setter adjusts for line shots by repositioning the course arrow. The tracer stream will move in and out of the slant plane as the arrowhead is rotated in and out of the slant plane. A tracer sensing of *High* on a crossing course indicates that the arrowhead is not in the slant plane and that it is above the slant plane. To place the arrowhead in the slant plane, the lead setter moves the arrowhead toward the slant plane by turning it away from himself. This movement pivots the lead screw toward the lead setter and, as a result, the gunpointers' eyepieces are raised (fig. 36). As the gunpointer brings his eyepieces back on the target, he lowers the tracer stream toward the slant plane. On an incoming course, if the tracer sensing is *Right*, the arrowhead is to the right of the slant plane; to bring the arrowhead toward the slant plane, the lead setter

turns the course arrow to the left. This motion pivots the lead screw to the right and, as a result, the gunpointers' eyepieces are turned to the right. As the lateral gunpointer moves his eyepieces back on the target, he moves the tracer stream to the left.

(2) The rule for adjusting line shots is to move the arrowhead in the direction the tracer stream must be moved to place it in the slant plane.

(*a*) For a *High,* move the arrowhead away from the lead setter.

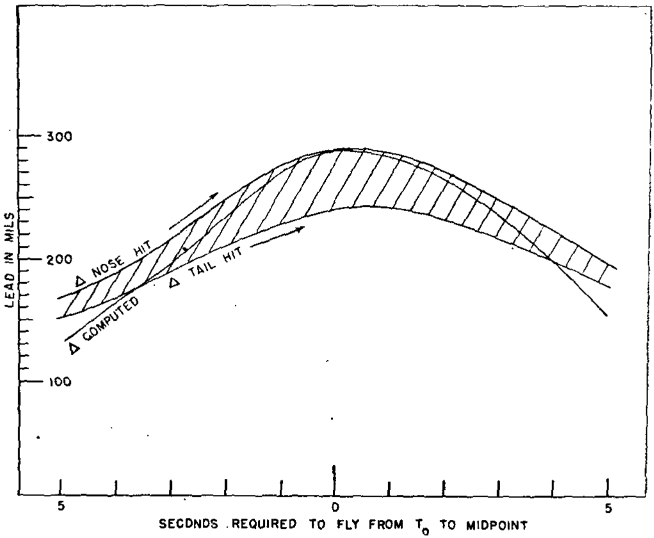

Figure 50. Comparison of generated lead with required lead, computing sights.

(*b*) For a *Low,* move the arrowhead toward the lead setter.

(*c*) For a *Right,* move the arrowhead to the left.

(*d*) For a *Left,* move the arrowhead to the right.

c. Lead adjustment. If the target course time permits, the lead setter adjusts for lead by resetting the speed in the computing box. Comparison of generated lead with required lead indicates a simple rule (fig. 50). Regardless of the type of

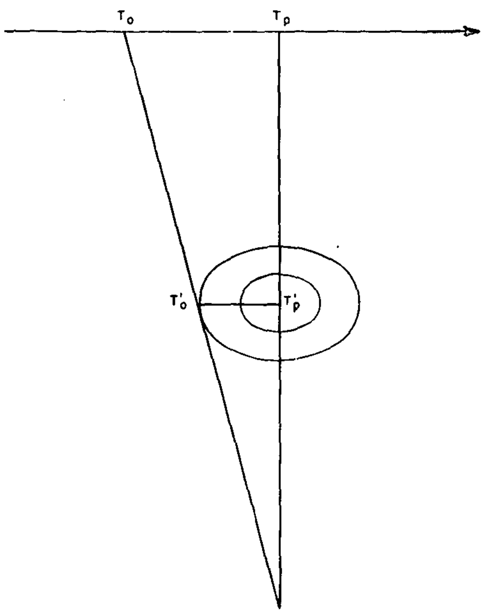

Figure 51. Principles of construction, speed ring sights.

target course or the position of the target along the course, when a silhouette is observed, the speed setting is increased; when an eclipse is observed, the speed setting is decreased. The rate of change of the speed settings is determined by the target speed; a high speed target requires a rapid rate of change, while a slower target requires a slower rate of change. The simple rule to remember is—

(1) *Astern increase.*

(2) *Ahead decrease.*

Section III. SPEED RING SIGHTS

207. GENERAL. Speed ring sights have been designed using the principle of similar triangles (fig. 51). Considering T_p at midpoint, then to make a sight triangle $G'T_o'T_p'$ similar to triangle GT_oT_p, speed ring sights place several concentric circles perpendicular to line D_p. The radius of the circle whose circumference intersects the line of sight forms side $T_o'T_p'$. The gunpointer varies the speed setting in the sight by selecting different speed rings and as a result different values for side $T_o'T_p'$. Because the speed ring sights have been designed with the angle $T_o'T_p'G'$ a constant of 90°, triangle $G'T_o'T_p'$ is similar to triangle GT_oT_p only at midpoint. The gunpointer compensates somewhat for this undesirable condition by careful speed settings as discussed in paragraph 208**c** (Link III). In order to fix the size of the concentric circles, speed ring sights have been designed for a range of 1,000 yards; the size of these circles

is dependent upon the length of the line $G'T_p'$ which distance the designer decides.

208. GUNNERY CHAIN. a. Link I. The line of sight is established when the gunpointers place the target within the scope of vision of the sight (fig. 52). This requirement is not very exacting in that, according to the above definition, gunpointers satisfy Link I no matter where within their sights they place the target. However, the additional links of the gunnery chain will position the target at one specific spot in the sights. Because the tar-

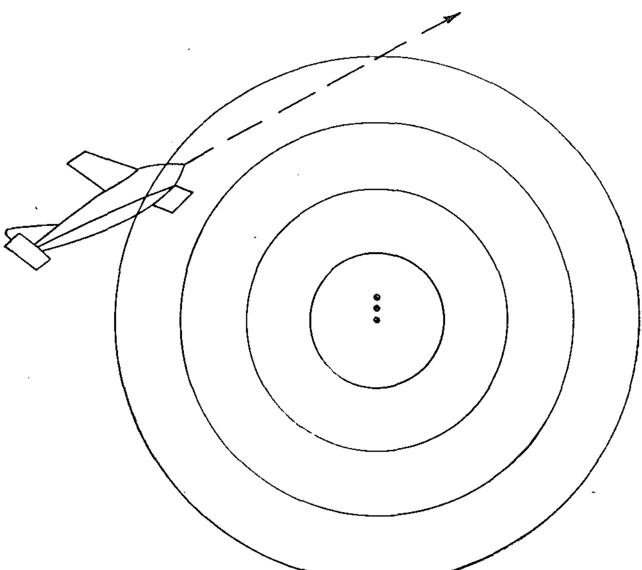

Figure 52. Link—Speed ring sights.

get is moving, Link I becomes a continuous operation.

b. Link II. In their sight picture, the gunpointers can visualize the slant plane. By extending the fuselage of the target, they can see the course line; point G' is near the eye. In figure 52, the slant plane is above the hub of the speed rings. The gunpointers also see the shooting plane in their sight picture. The line of sight is the line from G', a point very near the eye, to target; the axis of the gun bore, disregarding superelevation, is represented by the sight reference axis. Therefore, a visible line in the sight picture lying in

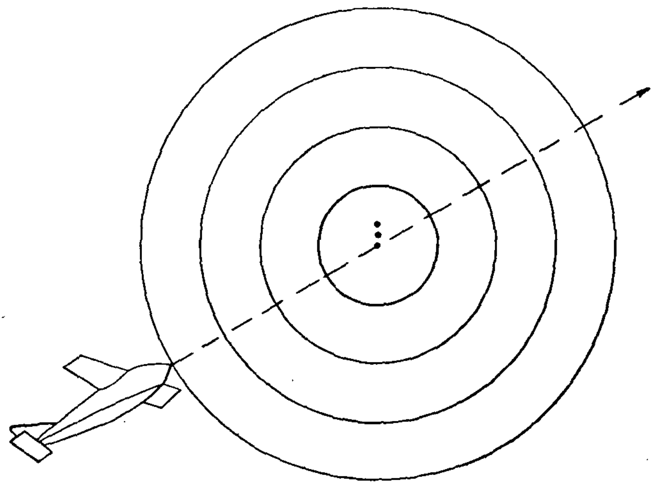

Figure 53. Link II—Speed ring sights.

the shooting plane is the line between the hub and the target. In figure 52, the shooting plane is not in the slant plane and the sights must be elevated until the hub lies on the course line (fig. 53). Consequently, to establish the shooting plane in the slant plane, point the target toward the hub. Because the target is moving and there is a difference between the angular height from eye to tail of plane and from eye to nose of plane, a target on a level course when observed in the sight appears to be climbing on the approaching leg, level at midpoint, and diving on the receding leg. This

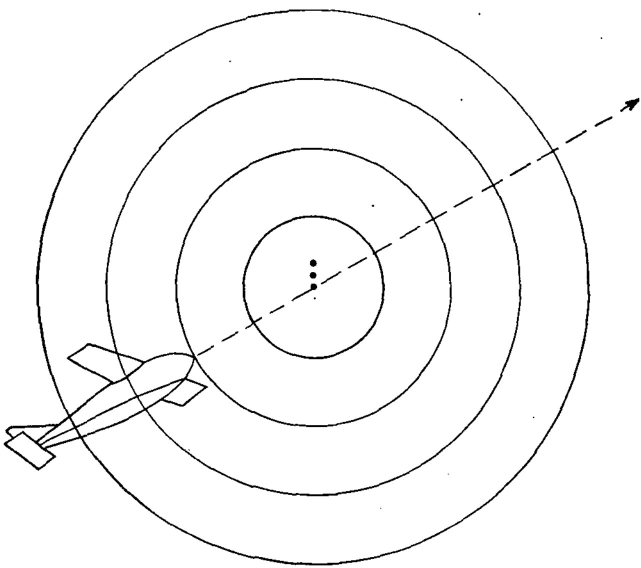

Figure 54. Link III—Speed ring sights.

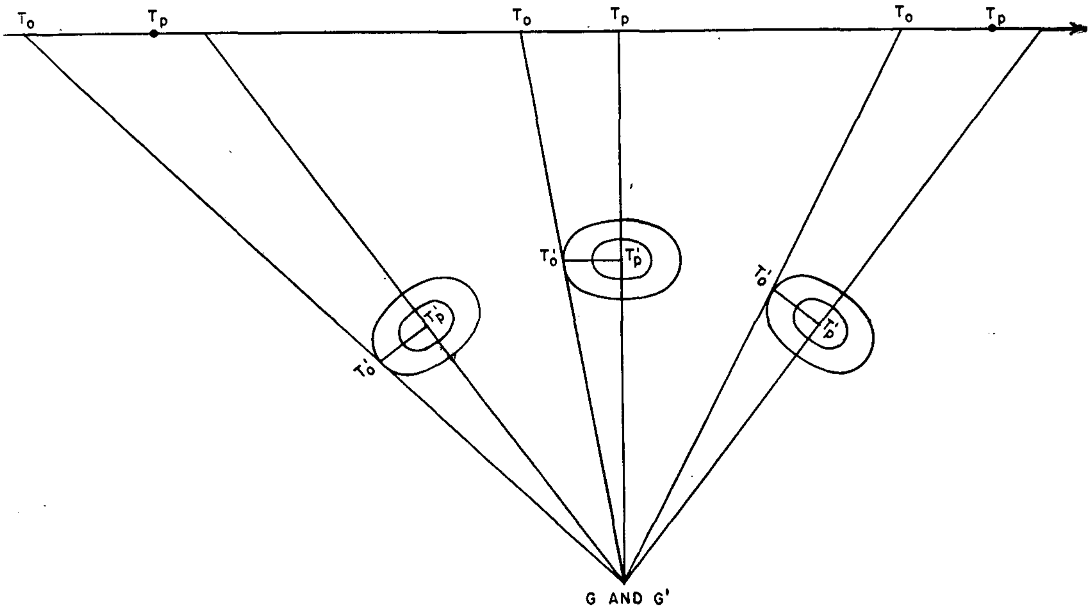

Figure 55. Generated lead effects, speed ring sights.

appearance of rotation about the hub is called *image spin* and makes Link II a continuous operation.

c. Link III.

(1) To establish correct lead, place the center of mass of the target on the speed ring representing three-fourths of the estimated speed and hold there throughout the entire firing course. In figures 52 and 53, assume the target to be flying at 400 miles per hour and each speed ring on the sight represents 100 miles per hour. The gunpointers move the sight along the course line until the center of mass of the target rests on the 300 miles per hour speed ring (fig. 54).

(2) Three-fourths estimated speed is used rather than full speed because full speed would produce fly-throughs only if D_m were 1,000 yards or more. Targets at this range are at the extremities of the effective hitting ranges of automatic weapons. With three-fourths speed set in the sight, there is a greater assurance of a fly-through for any course. Because the speed rings always are perpendicular to the sight reference axis, the angle $G'T_o'T_p'$ only equals α_s when T_p is at T_m with full speed in the sight. On the approaching leg and the receding leg, the

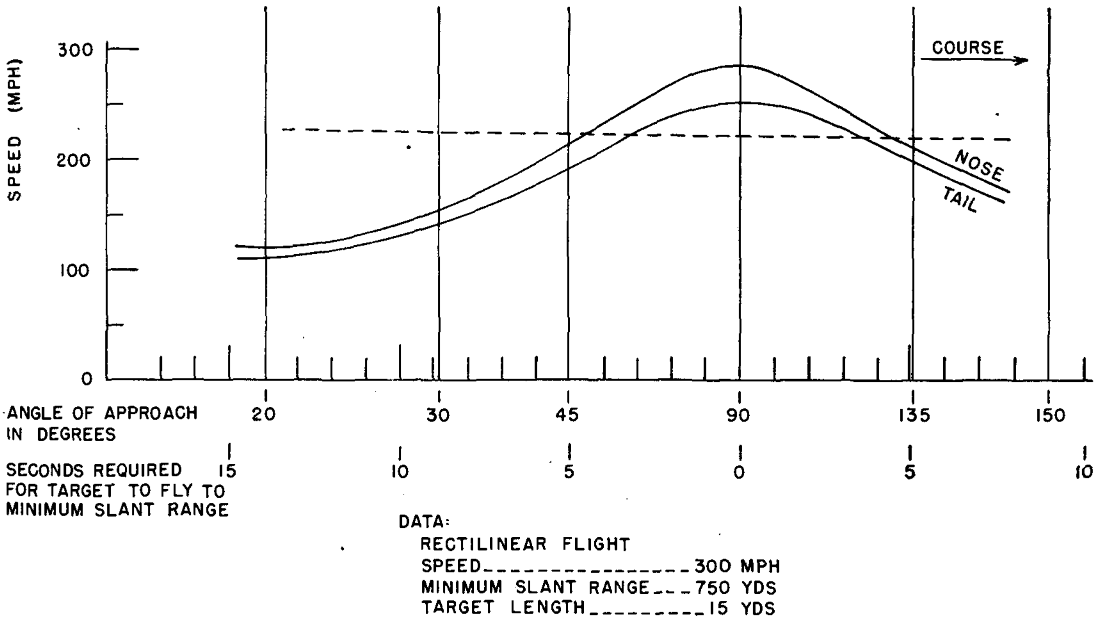

Figure 56. Comparison of generated lead with required lead, speed ring sights.

sine of the angle $G'T_o'T_p'$ is greater than the sine of α_s and, as a result, generated lead exceeds required lead (fig. 55). Tracking at three-fourths estimated speed produces possible fly-throughs on both the approaching and receding legs of the course and it is easy to use mathematically (fig. 56). One-half speed, though convenient to use mathematically, places the fly-through too far out on the course from midpoint and at extreme ranges of effective fire of automatic weapons.

d. Link IV. Superelevation is established in the sights as a fixed quantity during orientation. This fixed quantity is justified by the inherent crudeness of speed ring sights. The procedure for orienting speed ring sights and the values of superelevation are discussed under each specific type of speed ring sight.

209. 40-MM GUN SPEED RING SIGHT WITH COMPUTING SIGHT M7A1. a. Description. The speed ring sights are issued as an auxiliary fire control system to the computing sight M7A1. The front element of the sight consists of four speed rings and three pips. Each of the four speed rings represents, respectively, the required midpoint lead for a target traveling 100, 200, 300, and 400 miles per hour at a midpoint range (D_m) of 1,000 yards (fig. 10). The pip on the vertical wire is used to

establish the fixed value of superelevation during orientation. Two pips appear on the horizontal wire, one on either side of center. These pips represent the required midpoint lead for a 20-mile-per-hour target and are used for fire against moving land or naval targets. The rear element of the sight is a small circular peep sight.

b. Operation. The gunpointers line up the eye, the center of the rear element of the sight, a selected point on the front element of the sight, and the target. The selected point on the front element of the sight represents T_o, the hub of the front element of the sight represents T_p, and point G is represented by the center of the rear element of the sight.

c. Orientation.

(1) Place the axis of the gun bore on the orienting point (fig. 57).

(2) Check the sight picture. During orientation the gunpointer must be sure to line up his eye, the center of the rear element of the sight, the bottom intersection of the superelevation pip and the vertical wire, and the orienting point.

(3) If the vertical wire is not on the orienting point, loosen the two clamp nuts on the bracket of the rear element of the sight and move the rear element of the sight until the vertical wire appears on the orienting point. Tighten the clamp nuts.

(4) The superelevation pip should appear to touch the top of the orienting point. If this sight picture does not appear, loosen the clamp nut on the stem of the rear element of the sight and slide the rear element up or down until the pip appears to rest on the top of the orienting point. Tighten the clamp nut. This will produce approximately 9 mils superelevation.

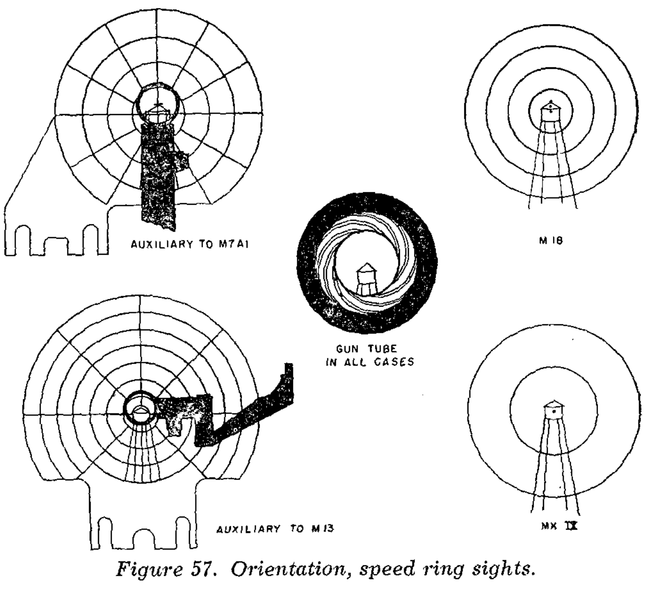

Figure 57. Orientation, speed ring sights.

210. 40-MM SPEED RING SIGHT WITH COMPUTING SIGHT M13. a. Description. The speed ring sight issued as an auxiliary fire control system to the computing sight M13 consists of a front element of eight speed rings and a rear element with a

small circular peep sight. The eight speed rings represent required midpoint leads for targets traveling 25, 100, 200, 300, 400, 500, 600 and 700 miles per hour at a midpoint range (D_m) of 1,000 yards (fig. 9).

b. Operation. The operation of this type speed ring sight is the same as for the speed ring sight with the computing sight M7A1.

c. Orientation.

(1) Place the axis of the gun bore on the orienting point (fig. 57).

(2) Check the sight picture. During orientation, the gunpointer must be sure to line up his eye, the center of the rear element, a point two-thirds of the distance up on the twelve o'clock radius of the 25-mile-per-hour speed ring, and the orienting point.

(3) If the twelve o'clock radius of the 25-mile-per-hour speed ring is not on the orienting point, loosen the clamp nut on the stem of the rear element of the sight and move the rear element right or left until the twelve o'clock radius of the sight is on the orienting point. Tighten the clamp nut.

(4) Superelevation is established by placing a point two-thirds of radius of the 25-mile-per-hour speed ring on the top of the orienting point. This is accomplished by loosening the clamp nuts on the bracket of the rear element of the sight

and moving the rear element up or down until that point rests on the top of the orienting point. Tighten the clamp nuts.

(5) ***Caution:*** Do not orient vertically by placing the upper circumference of the 25-mile-per-hour speed ring on the orienting point. This will introduce approximately 15 mils superelevation into the sight; this is an unreasonably excessive amount. Two-thirds of the radius of the 25-mile-per-hour speed ring is used to produce approximately 10 mils superelevation.

211. SPEED RING SIGHT M18. a. Description. The reflex sight M18 (fig. 16) is the primary fire control device on the multiple machine-gun mount M45 regardless of the type carriage used. The sight consists of a sight bracket which clamps to the cross bar of the M45 mount, and the sight mechanism itself. The sight mechanism is mounted on the sight bracket by sliding it into two guides on the bracket. The reticle of the sight is an etched metal plate, or pattern producing element, producing a pattern of four speed rings and three dots. The speed rings represent required midpoint leads for targets traveling 100, 200, 300 and 400 miles per hour at a midpoint range (D_m) of 1,000 yards. The lower dot is the hub of the reticle. The upper dot is used to establish superelevation during orientation and represents approximately 10 mils. The third dot is midway between the hub and the upper dot and represents approximately 5 mils superelevation.

b. **Operation.**

(1) The light rays necessary to illuminate the reticle come from one of two sources. First, for periods of restricted light, the sight has an electric bulb, the intensity of which is regulated by a rheostat which is controlled by a knob on the lamp housing. Second, for periods of normal daylight, the gunpointer can remove the artificial light and use direct sunlight; the artificial light is removed by grasping the handle on the right side of the sight, pulling out to release the pin, turning the handle 90° thus rotating the lamp housing clear of the reticle. Releasing the handle enables a spring action to lock the pin with the lamp housing in the open position. Light rays, regardless of source, pass through the reticle (fig. 58). The image of the reticle then is diverted 90° by the mirror and passes to the magnifying lens. From the lens, the image passes to the reflector; this reflector is a chemically treated glass plate which permits half of the light to pass through and be lost while the other half is diverted 90° to the gunpointer's eye. As in any mirror effect, the gunpointer sees the image of the reticle inside the reflector. Using the reflector's mirror qualities to see the image of the reticle, the gunpointer also uses the reflector as a window to see the

target through the glass. The gunpointer, therefore, sees two pictures, one superimposed on the other; one picture is the image of the reticle and the other is the picture of the target. The gunpointer then positions the two pictures so that the nose of the target points toward the hub of the reticle with the center of mass of the target on the speed ring representing three-fourths estimated target speed.

(2) The gunnery solution begins with the reticle.* Mathematically, the image of the reticle is constructed beginning at the optical center of the lens. Therefore, consider the light rays converging from the reticle to the optical center of the lens; however, instead of passing directly to the lens, the rays are reflected from the mirror though still converging. From the optical center of the lens, the image diverges and after being reflected from the reflector, the image continues its divergence as far as the gunpointer's eye can see. The image of the reticle can be said to create a cone with the vertex at the optical center of the lens. Therefore, at a range of 100 yards, the diameter of the image would appear to cover a certain distance, but at 1,000 yards that distance would appear to be ten times greater; thus, it is seen that the radii of the speed

*This paragraph does not attempt to explain the complex optical principles of this sight.

rings always subtend the same lead angle regardless of the range of the target. T_o is the point on the reticle representing the tracking point; T_p is represented by the hub of the reticle. G is represented by the optical center of the lens (fig. 59). The gunpointer in tracking assumes the position of a film slide projector operator. The image of the reticle is projected out

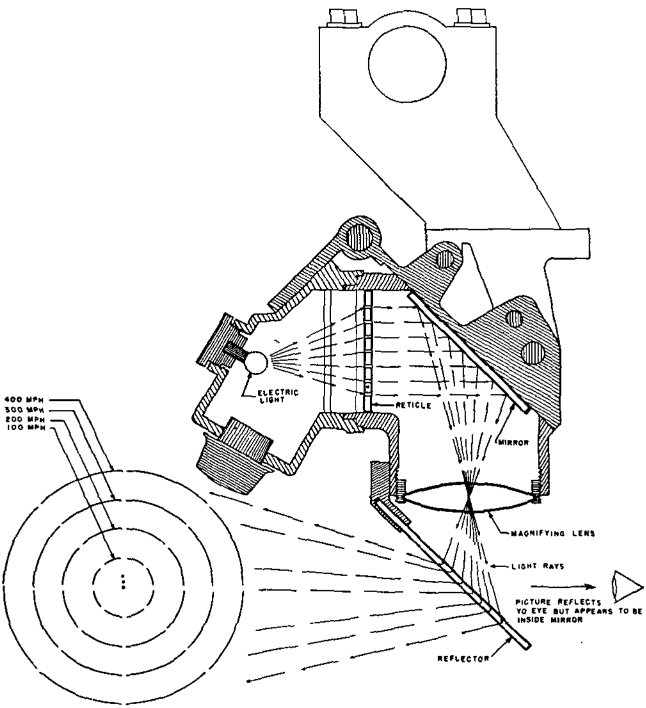

Figure 58. Cross section of speed ring sight M18 (graphical presentation only).

into space and finally appears to take shape on a screen at the target. The target becomes a fly on that imaginary screen. Just as a film slide projector operator can adjust his projector to place the picture anywhere on a screen, so the gunpointer can move his mount until the image of the reticle hits the fly (target) on the imaginary screen at any point he desires; that point is the center of mass of the target on the three-fourths estimated speed ring.

(3) The position of the gunpointer's eye does not affect the gunnery solution. The only requirement is that he look into the reflector so as to see enough of the image of the reticle to permit proper tracking.

c. Orientation.

(1) Place the axis of each machine gun bore on the orienting point (fig. 57).

(2) Check the sight picture.

(3) Adjust laterally until the upper dot is lined up with the orienting point. This is accomplished by loosening the azimuth clamp nut and turning the azimuth adjusting screw right or left until the upper dot is in line with the orienting point. Tighten the azimuth clamp nut.

(4) Adjust vertically by loosening the elevation clamp nut and turning the elevation adjusting screw until the upper dot rests on the top of the orienting point. Tighten the elevation clamp nut.

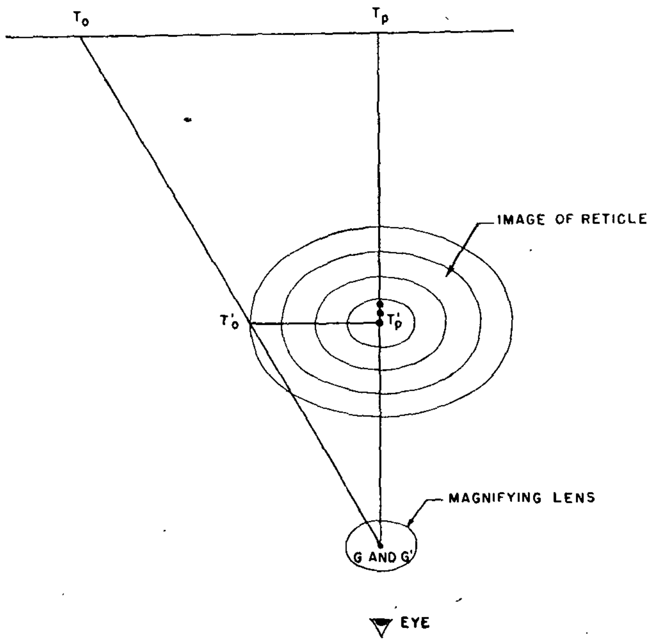

Figure 59. Principles of construction, speed ring sight M18.

212. SPEED RING SIGHT MARK IX. a. Description. The speed ring sight Mark IX (fig. 11) is the primary fire control device on the multiple machine-gun mount M45 when the speed ring sight M18 is not available. The sight consists of a sight bracket which clamps to the cross bar on the M45 mount, and the sight mechanism itself which is mounted on the sight bracket by clamps. The reticle is an etched surface which produces a pattern of two speed rings and one dot. The speed rings represent required midpoint leads for targets traveling

50 and 100 miles per hour at a midpoint range (D_m) of 1,000 yards. The dot is the hub of the reticle.

b. Operation.

(1) The light rays necessary to illuminate the reticle come from an electric bulb; there are two settings on the rheostat control knob, a DAY and a NIGHT position. When the rheostat knob is in the DAY position, the current bypasses all resistors, causing the lamp to burn at one intensity. When the rheostat is in the NIGHT position the current passes through a fixed resistor and a variable resistor; these resistors vary the intensity of the light in accordance with the further adjustment of the rheostat knob. There are two positions for the electric bulb. When inserted one way, the bulb burns a 6-candlepower filament; when inserted 180° opposite the 6-candlepower position, the bulb burns a 21-candlepower filament. The 21-candlepower filament is for the DAY position of the rheostat knob, while the 6-candlepower filament is for the NIGHT position. To insert the bulb properly, set the rheostat knob to DAY. Then insert the bulb, noticing its intensity; remove the bulb, rotate it 180° and reinsert it, again noticing its intensity. The brighter light indicates the proper position for DAY operation. For

night use, turn the bulb 180° with the rheostat knob on NIGHT.

(2) The light rays pass through the reticle to the magnifying lens (fig. 60). From the lens the image of the reticle passes to the reflector; this reflector is a chemically treated glass plate which permits half of the light to pass through it and be lost while the other half is diverted 90° to the gunpointer's eye. As in any mirror effect, the gunpointer sees the image of the reticle inside the reflector. Using the reflector's mirror qualities to see the image of the reticle, the gunpointer also uses the reflector as a window to see the target through the glass. The gunpointer, therefore, sees two pictures, one superimposed on the other; one picture is the image of the reticle while the other picture is the target. The gunpointer then positions these two pictures so that the nose of the target is pointed toward the hub of the reticle with the center of mass of the target on the speed ring representing three-fourths estimated target speed. Because of the lack of a sufficient number of speed rings in the sight, the gunpointer must track high speed targets by keeping both eyes open; one eye seeing the image of the reticle while the other eye sees the actual target outside the sight housing. He then places sufficient imaginary speed rings between the target

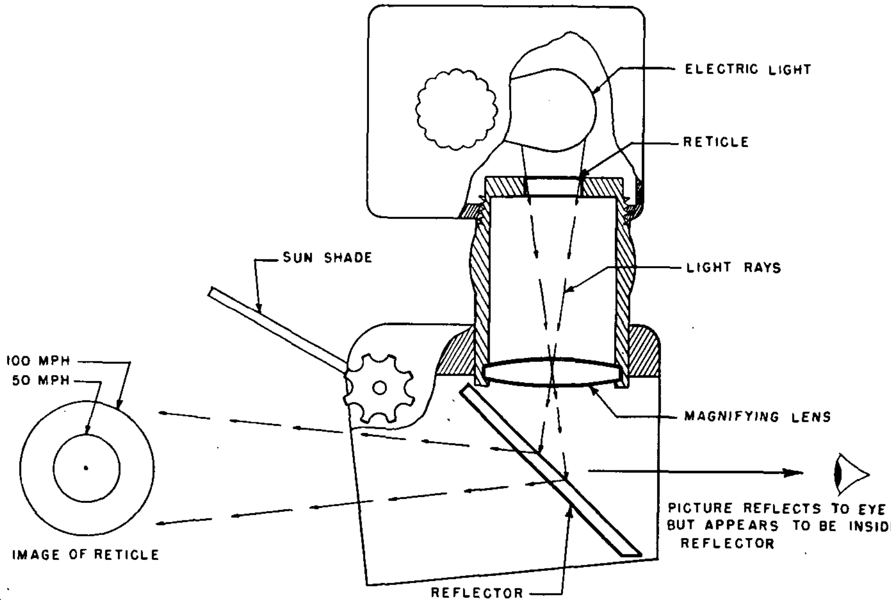

Figure 60. Cross section of speed ring sight Mark IX (graphical presentation only)

and the 100-mile-per-hour speed ring so as to track the center of mass of the target on the imaginary speed ring representing three-fourths the estimated target speed.

(3) The gunnery solution is the same as for the speed ring sight M18 except for the mirror between the reticle and the lens; the Mark IX sight has no mirror between these two parts. G' is the optical center of the lens; T_p' is the hub of the reticle; T_o' is the point on the reticle representing the intersection of the line of sight and the image of the reticle.

(4) The position of the gunpointer's eye does not affect the gunnery solution. The only requirement is that he look into the reflector so as to see enough of the image of the reticle to permit proper tracking.

c. Orientation.

(1) Place the axis of each machine-gun bore on the orienting point (fig. 57).

(2) Check the sight picture.

(3) Adjust vertically by loosening the elevation and azimuth clamp nuts and grasping the elevation adjusting lever. Rotate the cam until the orienting point rests at a point one-fourth of the distance up the twelve o'clock radius of the 50-mile-per-hour speed ring. Tighten the elevation and azimuth clamp nuts.

(4) Adjust laterally by loosening the azimuth clamp nut and grasping the sight. Rotate the sight until the dot is in line with the orienting point. Tighten the azimuth clamp nut.

213. FIRE ADJUSTMENT. Speed ring gunnery does not depend on tracer observation. If the gunpointers establish the four links of the gunnery chain as prescribed in this chapter, they will get fly-throughs. Therefore, gunpointers must establish the lead (speed ring representing three-fourths estimated speed) and hold that fixed load throughout the course, keeping the nose of the target pointed at the hub of the sight. If, during the firing, the gunpointer makes a positive tracer sensing, he should make any correction indicated by the sensing; nevertheless, he must realize his speed ring sights are effective without tracers. When cloud conditions, dust, and vibrations obscure his vision for tracer observation, he must continue to fire full automatic fire with confidence that he will get fly-throughs.

CHAPTER 16

OFF-CARRIAGE FIRE CONTROL

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214. GENERAL. a. The directors M5A2 and M5A3 provide the primary method of fire control for the 40-mm gun on the M2A1 mount. The director M5A3 is identical to the M5A2 director except that the azimuth rate has been increased from 20° per second to 30° per second; both directors incorporate the 30-inch coincidence range finder M10. Both the M5A2 and the M5A3 contain the latest modifications of the director M5 and the M5A1; these latter directors no longer are standard.

b. The director M5A3 employs the *rate-range* method of prediction. As the target is being tracked along its flight path, the instantaneous angular rate of azimuth (Σ_a) and elevation (Σ_e) are measured. These rates are multiplied by a selected time of flight of the projectile (t_X) to establish lead angles. The remote control system M15 transmits firing data in the form of electrical data to the gun which, by means of the oil gears M3, is laid continuously in firing azimuth (A_f) and quadrant elevation (ϕ) in accordance with the firing data computed by the director.

c. The director provides certain definite advantages over on-carriage sights in forging the links of the gunnery chain.

(1) Director fire control can be used effectively on targets at longer ranges.

(2) The director is located 13 to 15 feet from the gun, thereby reducing disturbances to trackers.

(3) Director fire control can be accomplished largely independent of tracer observation.

(4) The rules for director fire control are the same regardless of the direction of the target course.

d. References: FM 44–60 and TM 9–659.

215. THE GUNNERY CHAIN. a. Link I—Establishment of the line of sight. The elevation and azimuth trackers on the director establish the line of sight. The use of the aided tracking feature and magnifying telescopes greatly aid the trackers in maintaining the necessary smoothness in the continuous establishment of the line of sight. With proper training, Link I will be made a strong link in the gunnery chain.

b. Link II—Establishment of the shooting plane in the slant plane. The director computes azimuth and elevation lead angles separately and continuously. The azimuth and elevation firing data are transmitted continuously to the gun independently of each other. Even though azimuth and elevation

data are computed and transmitted separately, the net effect is to place the gun barrel in the slant plane, disregarding superelevation. Thus, Link II is accomplished indirectly. In order that the gun barrel be displaced properly with respect to the line of sight, the azimuth and elevation reference planes must be the same. This means that great care must be exercised in emplacing the fire unit; procedure for emplacing the fire unit is discussed in FM 44–60. Since the across-course aiming tolerance angles are extremely small, usually of the magnitude of one mil or less, no tolerance in the level of the fire unit can be allowed.

c. Link III—Establishment of the correct lead angle.

(1) When a target is being tracked with a director, the telescopes actually move in the slant plane and have a slant plane angular rate of travel. The horizontal and vertical components of this slant plane angular rate are continuously established in the variable speed drives and transmitted to the multiplying mechanisms. In the azimuth multiplying mechanism, the lateral angular rate is multiplied by a selected time of flight. The product of this multiplication is a horizontal lead angle which is transmitted to the firing azimuth differential where it is added to the present azimuth to produce firing azimuth. This process is similar in elevation. The result of the simultaneous production of a lateral and vertical lead

angle is the movement of the gun to establish the slant plane lead angle (Δ_G).

(2) The director M5A3 utilizes the fly-through principle to obtain hits. The director will produce accurate leads for only a portion of any course because of the inherent errors in the mechanism. This disadvantage may be overcome by the correct use of the range adjustment mechanism (par. 220). A study of the required lead and the director generated lead curves for typical courses illustrates the necessity for adjustment in order to increase fly-through time interval (fig. 61).

d. Link IV—Establishment of superelevation. Superelevation is computed automatically in the director based on a constant *K* factor (which is based on the muzzle velocity of a half worn gun and the effect of gravity on the projectile) multiplied by the cosine function of present angular height. The sum of the rate of change of present angular height and the rate of change of superelevation (obtained from the variable speed drive) is multiplied by the selected time of flight in the elevation prediction mechanism. This product is equal to the vertical lead angle plus superelevation. The vertical lead angle and superelevation then are added to present angular height in a differential to give quadrant elevation. The gun is continuously positioned in quadrant elevation by the remote control system.

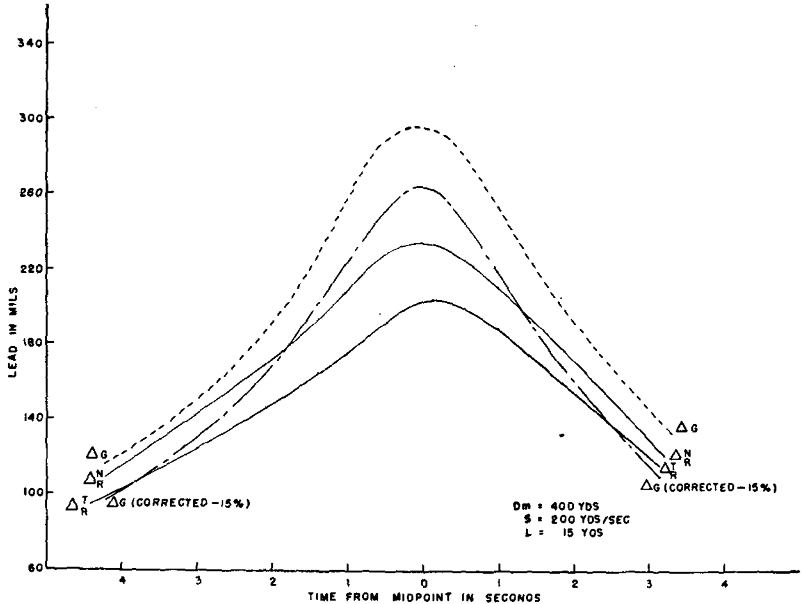


Figure 61①. Comparison of director generated lead with required lead.

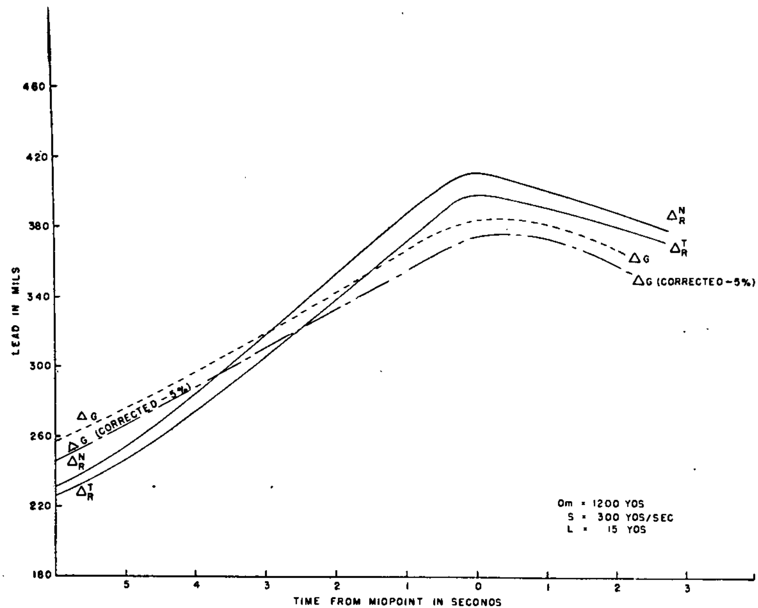


Figure 61②. Comparison of director generated lead with required lead.—Continued.

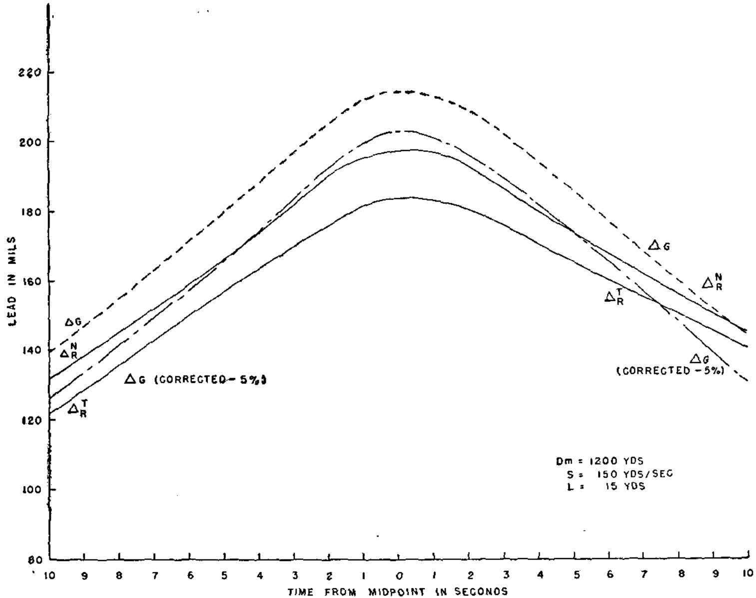


*Figure 61*③. *Comparison of director generated lead with required lead.*—Continued.

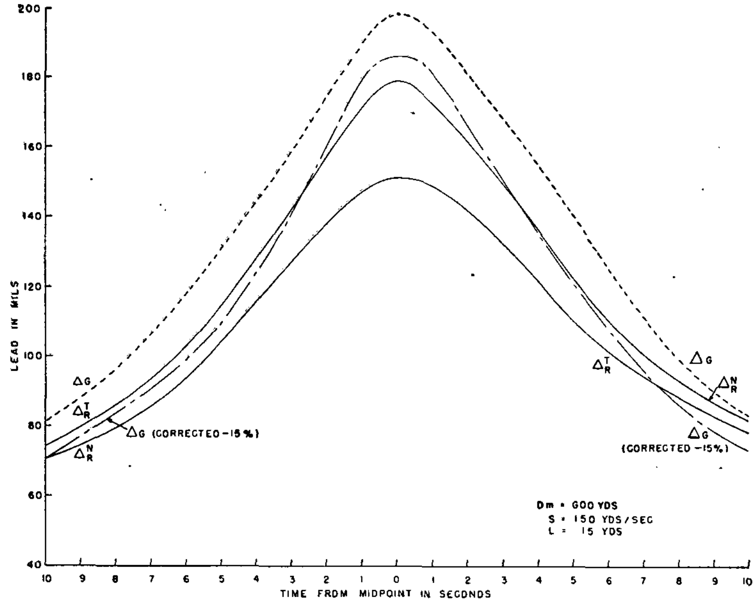


Figure 61④. Comparison of director generated lead with required lead.—Continued.

216. PREPARATION FOR FIRE. Preparation for fire consists of three distinct operations — emplacement, orientation, and calibration.

217. EMPLACEMENT. a. The gun must be solidly emplaced. It is desirable that the carriage, when emplaced and leveled, be as low as possible to the ground with only the jack foot plates in contact. As a guide, accurate level should be accomplished within two full turns of all jack cranks from the fully retracted position of the jack foot plates. Removal of earth from beneath the wheels of the carriage will be necessary in order to meet this condition. Such an emplacement will provide maximum stability for the gun.

b. Care must be taken to emplace the gun in such a position that, normally, firing will not take place when the gun is pointed over the drawbar end of the carriage. The construction of the drawbar and yoke assembly is such that it interferes with the ejection of empty cases and causes stoppages. When the gun is emplaced with the gun stay end of the carriage facing the center of the most probable sector of fire, the drawbar assembly will be pointing toward the director and in the dead area.

c. The director must be firmly and solidly emplaced with the horizontal braces between the tripod legs clear of the ground.

d. The director is emplaced as close to the gun as practical to reduce parallax (13 to 15 ft.).

e. Between firings, every opportunity must be used to check the level of the fire unit. No toler-

ance in the level of the gun or director can be accepted.

f. For methods and procedure for emplacement, see FM 44–60.

218. ORIENTATION. **a.** Orientation of the 40-mm fire unit is the establishment of parallelism between the axis of the gun bore and line of sight of the director telescopes. There are many methods of orienting the fire unit. However, at least one of the three methods named below can be used in any situation. These methods are—

(1) One pole parallelism for azimuth and gunners quadrant for elevation.

(2) Scribe mark parallelism for azimuth and gunners quadrant for elevation.

(3) Long-range convergence for both azimuth and elevation.

b. For methods and procedure in orientation, see FM 44–60.

219. CALIBRATION. **a. General.** Calibration, as applied to the 40-mm fire unit, is the determination and application to the gun of a correction in elevation necessary to obtain line shots. Determination of the magnitude of this correction is based on a firing problem. Assuming correct emplacement and exact orientation, there are several factors which might preclude the obtaining of line shots. These factors are the vertical parallax between the director and the gun, the loss of muzzle velocity due to erosion, the ballistic differential

effects, and the errors inherent in the director. The total elevation calibration correction is determined by a procedure called *trial fire* and adjusted, if necessary, based on a dynamic check problem

b. Trial fire.

(1) Trial fire provides for an over-all operational check of the fire unit as well as the determination of an elevation calibration correction. During trial fire the functioning of the gun also may be checked. When trial fire is completed, the stability of the emplaced mount and the length of recoil may be checked. As a result of trial fire, gross errors in leveling and in orientation may be detected. However, if the gun and the director are in perfect adjustment, properly emplaced, and accurately oriented, the elevation calibration determined should be the correction necessary to overcome—

(*a*) The vertical parallax between the gun and the director.

(*b*) The normal loss of muzzle velocity for a tube that is more than half worn.

(*c*) The small correction for differential effects.

(2) Since trial fire may not be permitted under combat conditions, it is necessary to perfect the procedure for emplacing and orienting the fire unit and to maintain an up-to-date record of the correct calibration correction during the training pe-

riod. An analysis of trial fires fired during training will show any conditions in the matériel that require correction. Continued emphasis on proper procedure in adjusting, emplacing, and orienting and proper analysis of trial fire during training will make the firing of trial fire in combat unnecessary.

(3) *Procedure.*

(*a*) Trial shots are fired at an imaginary target flying a circular course around the gun position at a constant speed and altitude.

(*b*) To prepare the director for trial fire, it is necessary to do the following:

1. Set in a range of about 1,500 yards.

2. Set the elevation scope at an angular height of from 20° to 30°.

3. Produce superelevation for the range and angular height selected by turning on the elevation rate motor switch, engaging the elevation rate setting clutch, and stopping the negative creep of the elevation fine data dial. Turn off the elevation rate motor switch.

4. Engage the azimuth rate setting clutch, turn on the azimuth rate motor switch, and set in one-fourth to one-third of a handwheel turn.

5. As soon as the azimuth rate has been set in the director, engage the azimuth and elevation switches at the gun. Each tracker puts his eye to his telescope to observe the tracer streak. When the gun points along the gun-director line, the shot is fired. To record the path of the tracers, each tracker must draw, immediately after each shot is fired, his impression of what he has seen (fig. 62).

(4) The precise nature of the appearance of a tracer streak in a director telescope in trial fire procedure depends upon—

(*a*) Range set into the director.

(*b*) Rate set into the director.

(*c*) Location of the director relative to the gun at the instant of firing.

(*d*) Angle of elevation of the gun and director.

(5) Two shots must be fired; one with the gun and director traversing to the left, and the other with the gun and director traversing to the right. If excessive displacement of the tracer pattern intersection is noted, level and orientation should be checked immediately. If the gun or director has been thrown out of level, the rounds fired must be considered as settling rounds and trial fire must be repeated. Unless the gun is fired when it is laid precisely along the gun-director

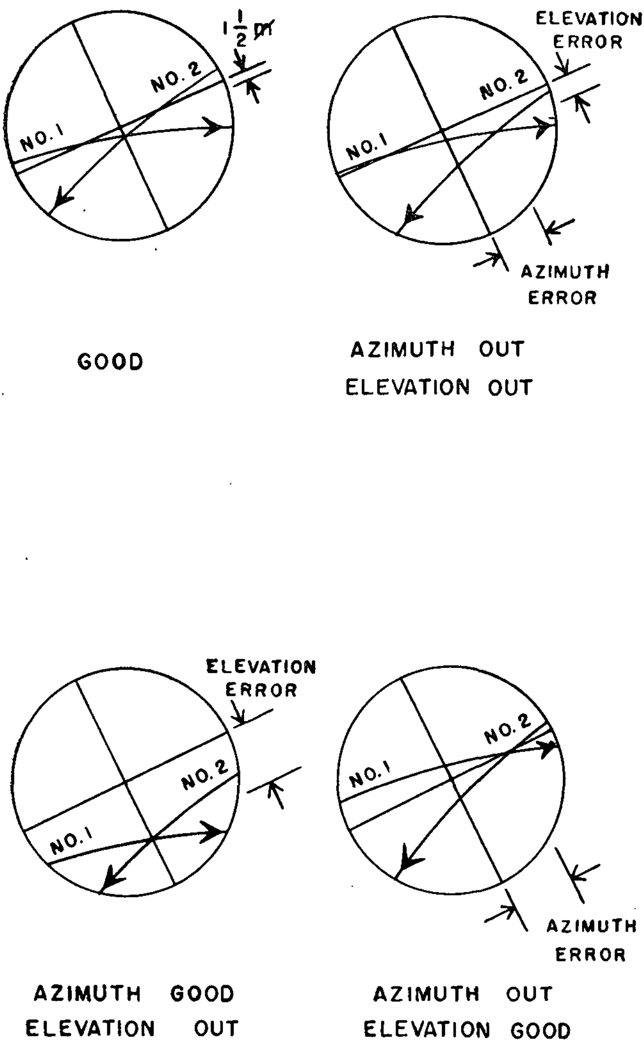
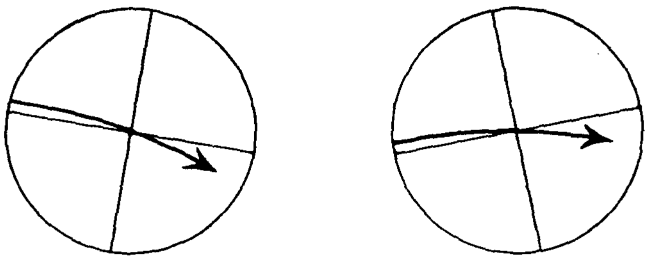


Figure 62. Trackers' picture of trial shots.

line, a lateral displacement of the tracer intersection is to be expected. Therefore, small lateral displacement should not be construed as errors in azimuth orientation.

(6) Figure 63 shows the general appearance of the tracer pattern in the director telescopes. The displacement of the tracer



ELEVATION TELESCOPE AZIMUTH TELESCOPE

Figure 63. Appearance of tracers in director telescopes.

pattern intersection indicates the sum of the errors in leveling, in orienting, or in loss of muzzle velocity; assuming proper adjustment of the fire unit, proper developed muzzle velocity, and proper leveling and orienting, an intersection should never occur more than two mils below the horizontal cross hair.

c. Analysis of trial fire.

(1) If all the influencing factors are in order, the intersection of the two tracer streaks must coincide almost exactly with the in-

tersection of the telescope cross hairs. The gun, at the time it is fired, is pointing above the imaginary target by the amount of the superelevation angle, and ahead of it the amount of deflection in azimuth. At any given angular height, the range governs the superelevation angle. Therefore, after 2 seconds of flight, if the range is set at 1,500 yards, gravity drop causes the tracer to cross the horizontal cross hair. For a constant azimuth tracking rate, the range also determines the azimuth deflection angle between the gun and the director. After 2 seconds of flight, the director should be at the same azimuth at which the gun was pointing when fired, and the tracer streak should cross the vertical cross hair. If it crosses both cross hairs at the same time, it must cross their intersection. Then, and only then, could a target carried on the intersection of the cross hairs of the telescopes be hit.

(2) Two trial shots must be fired because compensating errors might cause one of the tracers to cross the intersection when it is fired at a range other than that set into the director. Two shots fired from opposite directions always intersect one another at the range set into the director. It is this intersection of the tracer streaks which is the significant point and which must be compared with the cross hair

intersection. The elevation calibration correction is based upon the vertical displacement of the tracer intersection from the horizontal cross hair. The reticles are graduated in 10-mil intervals to assist in determining the magnitude of the correction.

(3) The shots should be fired when the gun, in its traverse, is pointed along the gun-director line. This removes the azimuth error due to the displacement of the director from the gun. The vertical parallax between the gun and the director causes a very small deviation in elevation (about 1½ mils) because the axis of the bore is lower than the line of sight of the director. In the director telescopes, 1½ mils is very small and if the tracer streaks do not pass close to the cross hair intersection, level and orientation must be corrected.

(4) When orientation is not correct, the tracer streaks intersect one another at the range set, but the telescope field, including the cross hairs, is moved laterally and/or vertically. For instance, with the gun out of orientation too far to the right, the trajectory is to the right, and the tracer intersection appears to the right of the cross hair intersection.

(5) The point at which the tracer streaks first appear and are last seen in the field of

the telescopes might be above or below the horizontal cross hair, depending upon the range and angular height set into the director. Under the conditions recommended for firing trial shots, they usually appear to enter below the horizontal cross hair, rise to a tangency at the cross hair intersection, and finally drop away as they leave the telescope field.

(6) The amount of curvature seen in the tracer streak depends primarily upon the magnitude of the azimuth rate. If a rate equivalent to a half handwheel turn is applied, the path approaches a straight line coinciding with the horizontal cross hair. Then it becomes impossible to determine the point of intersection and the trial fire is meaningless. An azimuth rate of one-fourth to one-third handwheel turn produces the best results.

(7) Poor leveling or orientation, as indicated by a lack of trial shot intersections, must never be used as a basis for tracking-off. Effective fire cannot be expected unless intersections are achieved. Line II of the gunnery chain cannot be satisfied by *track off* (par. 223).

d. Application of calibrations. Elevation calibration corrections are applied to the gun as follows:

(1) Turn off the director elevation rate motor switch and block the elevation handwheel, the elevation telescope being at any elevation between $+5°$ and $+30°$.

(2) Engage the elevation switch at the gun.

(3) Place the gunner's quadrant on the breech casing and adjust the gunners quadrant to bring the level bubble to center.

(4) Note the reading on the gunner's quadrant, add or subtract calibration, as necessary, and set the gunners quadrant to the new reading.

(5) Disengage the elevation boresighting clutch, place the gunner's quadrant on the breech casing and manually elevate or depress the gun as necessary to bring the level bubble to center.

(6) When the level bubble is centered, engage the elevation boresighting clutch.

e. Dynamic check.

(1) This procedure is a check on the accuracy of the elevation calibration correction as determined previously by trial fire. Such a check is necessary for two reasons. First, there is a chance for errors in the elevation calibration correction because trial fire is based on the interpretations of the tracer paths as observed by the trackers. The accuracy of the tracker's sketches will improve with experience. Second, there is basis for error in that trial fire alone produces a correction for but one point in the field of fire. Because of inherent prediction errors in the di-

rector, it is necessary to check the accuracy of fire so far as the obtaining of line shots is concerned throughout the field of fire. The dynamic check performs this function.

(2) Performance of the dynamic check includes firing at a towed target on two or more courses. From observation of the fire it is determined whether or not a majority of line shots were obtained and, if not, whether the shots were generally above or below the target. If a majority of line shots were obtained, it can be assumed that the elevation calibration correction based on trial fire is valid; if a majority of the shots appear either above or below, necessity for additional correction is indicated. Under the latter condition, the chief of section should determine the magnitude of the new correction based on his own and the trackers' sensings. If trial fire has been conducted properly, these corrections should be of small magnitude (not exceeding 3 mils). Corrections are applied to the gun in the same manner as are trial fire calibrations. Dynamic check is continued until the chief of section is satisfied that a majority of line shots are being obtained.

(3) The validity of the dynamic check is based on the accuracy and efficiency of the trackers. Until the trackers have reached peak proficiency in their duties,

no reliable data can be obtained from firing dynamic check problems.

f. Use of elevation calibration data for subsequent firings.

(1) A record of elevation calibration corrections should be kept by the platoon leader and the chief of section for each weapon. If up-to-date records are maintained, they will be of great value in situations where trial fire and dynamic check problems are either prohibited or time is lacking to fire them. In such a situation it would only be necessary to apply to the gun the known elevation calibration correction from the most recent firing. This procedure should produce results as effective as those attained during the last firing of the weapon.

(2) However, it must be remembered that the elevation calibration correction is not a static value. It will vary, depending primarily upon tube erosion. All firing must be carefully observed to insure that valid elevation calibration corrections are utilized at all times.

220. RANGE ADJUSTMENTS FOR M5A2 AND M5A3 DIRECTORS. a. General. In the director M5A2 or M5A3 continuous present slant range to the target is set into the director multiplying mechanism by a range finder and servo mechanism. In the design of the basic director M5 certain errors, both in method and construction, were known

to exist and deliberately tolerated because they had no adverse effect on the method of fire control used. In the earlier models of the director (M5 and M5A1) a fixed range was set and held until a fly-through was obtained. This method now is used only as an emergency method of fire control for the director M5A2 or M5A3 and is discussed in paragraph 222.

b. Range percentage correction. Since the director M5A2 or M5A3 computes the magnitude of lead continuously, the inherent errors must be taken into consideration. Generally, the director tends to overcompute. A range adjustment mechanism is provided for applying range percentage corrections. The mechanism consists of a range adjustment lever, which is spring loaded and must be operated manually, and a fixed correction knob that will hold any correction applied until manually returned to zero position.

c. Initial spot correction. As a result of firing tests at target speeds up to 300 miles per hour and computations and comparison of required and generated lead curves for speeds up to 600 miles per hour, using various midpoint ranges, it was found that the following initial corrections were most applicable (fig. 61):

Approximate D_m	Spot
500 yards	— 15 percent
1,000 yards	— 5 percent

The above spot corrections are introduced prior to firing, using the fixed correction knob. The correction is applied as soon as target midpoint range

can be roughly estimated. The initial spot corrections were determined assuming a properly adjusted director and range finder. These fixed corrections should be used until firing experience in a particular situation indicates that different corrections are required.

d. Standby spot correction. A standby spot correction of —10 percent should be kept on the fixed correction knob at all times as a safety precaution in the event that the range spotter, due to excitement or other causes, forgets to apply the above spot corrections. A —10 percent correction will assure a fly-through on combat targets.

e. Fire adjustment using the range adjustment lever. To obtain information for range adjustment, the range spotter has three methods of observing tracers.

(1) The range finder is designed so that as a range spotter looks in his eyepiece, he sees two tracers simultaneously for each round fired. The tracers appear to be apart at first and gradually come closer together until they finally merge. After they merge they gradually start to spread out again. The tracers merge at the range of the target; if the merge occurs ahead of the target, magnitude of lead is too great and range must be reduced, and if they merge astern of the target lead is too small and range must be increased. The principal weakness of tracer observation lies in the fact that because of poor tracers, light conditions,

and high target speeds, the two tracer images generally cannot be seen. Even the most experienced range spotters have considerable difficulty seeing the two tracer images merge. This is a poor method.

(2) The second method, and the one found most satisfactory, is for the range spotter to wear red glasses and sense tracers for silhouettes and eclipses.

(3) The third method, which also gives satisfactory results, is a combination of the first two methods. The range spotter looks through his eyepiece and observes for silhouettes and eclipses. When using this method, the range spotter will be aided by seeing an occasional tracer merge.

f. Application of spot correction. Inasmuch as most rounds have very nearly correct lead and lead is computed continuously, if one definite silhouette or eclipse is observed, it can be used as a basis for a range adjustment. If a silhouette is observed, the range spotter, using the range adjustment lever, applies a gradual plus spot; the speed of the correction is in accordance with the speed of the target; a high speed target requires a rapid rate of correction, while a slower target requires a slower rate of correction. If an eclipse is observed, a minus correction is applied in the same manner. It should be understood that although manipulation of the spring loaded lever to

adjust fire is feasible on the target range, it will be the exception rather than the rule in engagement of combat targets because of the relatively short time of engagement to be expected. It is mandatory that directors be kept in proper adjustment and operating condition in order to insure that the recommended initial spots are applicable at all times.

221. RATE OF FIRE. The rate of fire for the 40-mm gun fire unit should be full automatic fire. This is predicated on the fact that the fly-through time interval for combat targets is critically short and the possibility of hitting is increased, proportional to the rate of fire. When ammunition for training is limited, commanders will restrict the firing to selected portions of the target course line rather than reduce the rate of fire of a crew properly trained to fire automatic fire.

222. EMERGENCY USE OF DIRECTOR M5A2. In the event the range finder becomes inoperative, a spare range handwheel is provided and may be fitted in a receptacle in the director servo mechanism; this provides for setting in the range manually. In this method of fire control, on the approaching leg, the range spotter sets into the director a range that is approximately 300 yards shorter than the estimated present range to the target. The range spotter then holds that range in the director until he observes a hit, or tracers change from astern to ahead, or until the target has moved to a shorter present range than that set

in the director. He then repeats his adjustment of range to a setting reading less than present range, and continues the above procedure to midpoint.

Caution: Never set in a range that is less than the midpoint range; otherwise a hit will be very improbable.

On the receding leg, a range greater than the present range by approximately 300 yards is set into the director. The range spotter then holds that range in the director until he observes a hit, or tracers change from ahead to astern, or until the target has moved to a greater present range than that set in the director. He then repeats his adjustment of range to a setting reading more than present range, and continues the above procedure until the target flies out of range of the gun.

223. TRACK OFF. a. Track off is defined as any procedure whereby the tracking is conducted with target held in the telescopes at any position in the field of view other than the cross hair intersection in order to obtain line shots on the target.

b. Careful maintenance and accurate adjustment of equipment, and accurate orientation and leveling minimize or preclude the need for track off.

c. In the early stages of training, track off should never be employed; in advanced stages of training, track off should never be attempted until the range section has proven its ability to track accurately.

d. There are two special situations when track off may be permitted:

(1) (*a*) On an incoming course, especially when the direction of approach is perpendicular to the gun-director line, the tracers may appear either right or left of the target the amount of gun-director parallax distance. If such is the case, it is necessary to track off in order to place the tracers on the target.

(*b*) On a crossing course, the tracers have a tendency to go above the target as it approaches midpoint. This can be compensated for by having the vertical tracker track off slightly below the center of mass of the target.

(2) In an emergency, due either to the fact that the gun crew has not had time to orient and adjust the equipment accurately, or that the orientation and adjustment of the equipment is thrown out during firing, it may be necessary to track off in order to obtain line shots. At least two successive shots, deviating in the same direction, must be observed before attempting track off.

e. Track off is useless unless tracking is steady. By tracking off, an attempt is made to move the tracer to the target.

f. Track off is employed when necessary in either azimuth or elevation, never in both at the same time.

(1) *Crossing courses.* For crossing targets, high or low rounds are brought to the target by the elevation tracker making a slight correction to his tracking in the following manner:

(*a*) He determines that his tracking is steady.

(*b*) When a number of tracers (in no case less than two) are observed consistently crossing the vertical cross hair with one sensing and with approximately the same magnitude, he will measure with his eye to the point where the average tracer cuts the vertical cross hair. This is the "track off point."

(*c*) If the tracers are observed high, he will gradually depress the telescope until the target approaches the point. Thus he will track approximately the same amount below the target as the tracers passed above it. The tracers will then appear on or near the target (fig. 64).

(*d*) Having once obtained line shots in this manner, the elevation tracker must continue to track steadily on the new tracking point. It will be necessary to change the amount of track off to maintain line shots. These changes must be made gradually to avoid over correcting.

(*e*) Should the tracers appear low, the elevation tracker must carry out the same procedure, but gradually elevate the telescope until the target approaches the point where the tracers were cutting the vertical cross hair.

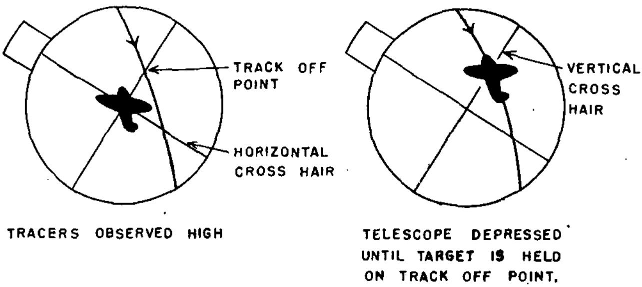


Figure 64. Track off in elevation.

(2) *Incoming or outgoing courses.* For incoming or outgoing targets, nonline shots appear right or left, and are brought onto the line of sight by the azimuth tracker making slight adjustments in the following manner:

(*a*) He determines that his tracking is steady.

(*b*) When a number of tracers (in no case less than two) are observed consistently crossing the horizontal cross hair with one sensing and with approximately the same magnitude, he measures with his eye the point where the average tracer cuts the horizontal cross hair; this is the "track off point."

(*c*) If the tracers are observed to the left, he traverses to the right until the target approaches that point. Thus, he tracks approximately the same amount to the right of the target as the tracers passed to the left of it. The tracers then will appear on or near the line of sight. (fig. 65).

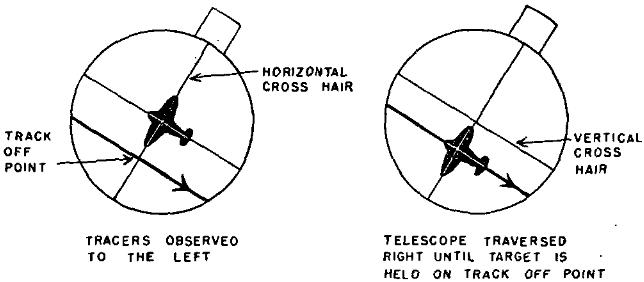


Figure 65. Track off in azimuth.

g. Track off precautions:

(1) Tracking must be absolutely steady before any track off is attempted. Corrections made on unsteady tracking are worse than useless.

(2) When tracking off, it is very difficult to track steadily. The amount has to be estimated by the eye. In order to track off by a constant number of mils, the line distance varies as the range changes. The problem is additionally complicated by the rotation of the field of view.

(3) The correction must always be a small one. It is better to bring the rounds slowly onto the line of sight from one direction by making more than one small correction, rather than by making one large correction, overshooting the mark, and having to come back again.

(4) There is usually more than one round in the air at one time, the tracker, therefore, normally will not see the result of any correction until at least the second round after the one on which he based his corrections.

(5) It is necessary that the trackers know the meaning of crossing and incoming courses so that both trackers will not correct (track off) on the same round.

(6) The mechanisms in the director which predict elevation deflections are such that if errors are to occur, they will most likely occur when maximum elevation rates are reached. Maximum upward elevation rate is determined by the elevation tracker when he feels the rate be gin to decrease on the approaching leg. Maximum downward elevation rate is determined when he feels the rate begin to decrease on the receding leg. By noting this rule it is possible for the elevation tracker to anticipate nonline shots and be prepared to correct them as prescribed in the preceding discussion.

h. Whenever it is necessary to track off on a course, investigate the cause at the first opportunity. Usually the trouble can be found in orientation or level, and must be remedied. Regardless of how good the trackers are, they cannot possibly obtain as many line shots by tracking off as they can by good tracking when the equipment is properly set up. The number of possible hits is directly proportional to the number of line shots.

CHAPTER 17

TARGET SELECTION

224. GENERAL. If antiaircraft fire is to be effective, it is necessary for all elements of attacking aircraft to be engaged. To accomplish this task, it is necessary that a system of target selection be adopted.

225. SINGLE AIRCRAFT ATTACK. When a defended objective is attacked by a single aircraft, there is no problem of target selection. All the weapons fire on the aircraft when it is within range. It is necessary, however, that each fire unit continue careful observation of its sector to insure against surprise attack coming from another direction.

226. MULTIPLE AIRCRAFT ATTACK. a. General. In multiple aircraft attacks, all the fire units must not engage the same target. In most cases, it will be necessary for the local commander to prescribe rules of engagement. However, the system described below will serve as one method or example of target selection.

b. Target designation.

(1) *Line formations.* Targets flying in a line will be designated by their respective positions in the formation, the leading aircraft being number 1, and the aircraft

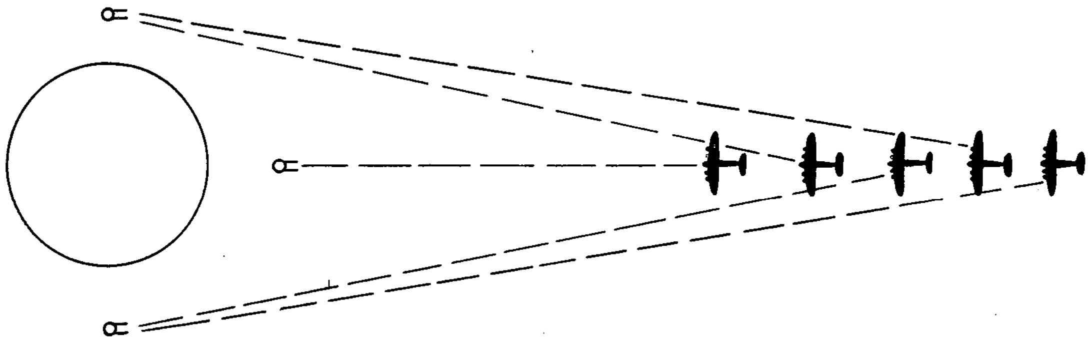


Figure 66. Target designation line formation.

immediately behind being number 2 (fig. 66).

(2) *V-formations.* The leading aircraft will be designated as number 1 and is the only aircraft designated by fire units seeing the formation as incoming. Targets in a V-formation seen as crossing will be designated from front to rear by their respective positions in the near wing of the formation. The leading aircraft is number 1 for fire units on both flanks of the course (fig. 67).

c. Basic guides.

(1) Targets not already fired on by other weapons normally will be engaged in preference to those already fired on.

(2) Targets approaching a position on an incoming course normally will be engaged in preference to those on a crossing course.

(3) Those fire units seeing the flight as an incoming course, will fire on the leading plane of the formation.

(4) Those fire units seeing the same flight as a crossing course from right to left, will engage an aircraft in the near wing of the V-formation; if the aircraft are in line, they will engage the third aircraft in the formation. In the event that the aircraft become heavily engaged by down-course weapons, fire may be shifted to another plane in a V-formation, or to the fifth aircraft in a line formation.

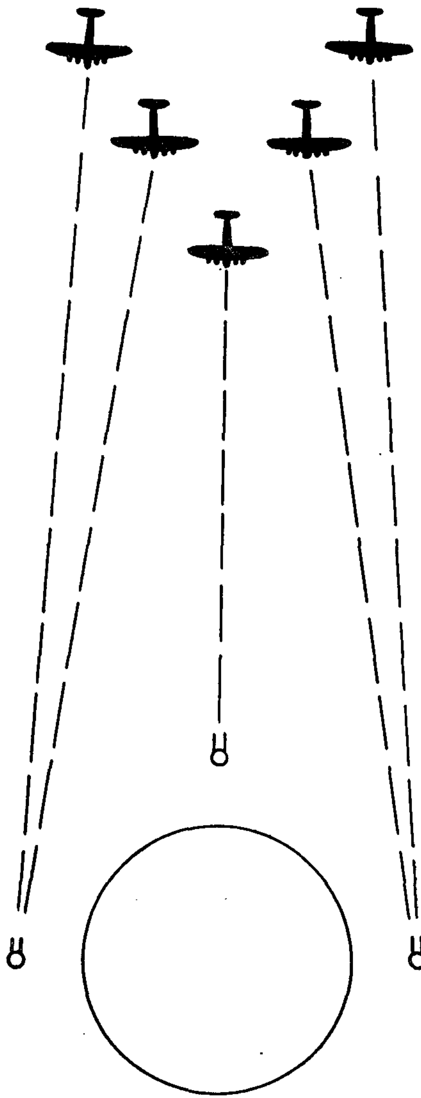


Figure 67. Target designation, V-formation.

CHAPTER 18

FIRE AT MOVING GROUND AND NAVAL TARGETS

227. GENERAL. Antiaircraft artillery automatic weapons may be assigned a surface mission against ground or naval targets.

228. COMPARISON OF AIR TARGETS WITH GROUND TARGETS. **a.** Air targets have great speed and maneuverability and are, therefore, harder to track than the relatively slower ground or naval targets.

b. The antiaircraft artillery gunner has no reference point in the sky to aid him in sensing his rounds; he must depend on line shots. The gunner in ground fire can use the splash or burst of the rounds on the ground to sense the shots.

c. In antiaircraft gunnery, the lead is large and is expressed as an angle. This angle is constantly changing and presents a difficult problem. In terrestrial gunnery, the slow speed of the target allows the lead to be expressed in apparent target lengths that can be estimated with reasonable accuracy.

d. Antiaircraft sight devices solve for superelevation expressed as an angle; this superelevation angle is either variable or fixed, depending on the

device. For terrestrial firing, superelevation can be estimated by a rule of thumb. For example, the superelevation required on a ground target at 600 yards range is about one target height.

229. APPARENT TARGET LENGTH LEAD. Leads for ground or naval targets are expressed in apparent target lengths. For example, an opening range of 600 yards and a target speed of 20 miles per hour requires one apparent target length lead for a target 6 yards long. The approximate required lead can be calculated by the following formula:

Lead $= RS/L$

where R equals range in thousands of yards.

S equals speed in yards per second.

L equals target length in yards.

230. USE OF SIGHTING SYSTEMS. a. General. When antiaircraft artillery protection is the mission of the automatic weapons, the sighting devices are oriented with superelevation included. If the primary mission is ground support, it is desirable that the sighting devices be oriented without superelevation being included. This can be accomplished with the speed ring sights but not with the computing sights.

b. Speed ring sights. When ground support is the mission, the speed ring sights are oriented with superelevation excluded; that is, the sight reference axis is parallel to the gun bore. In certain cases, the correct superelevation for a particular range may be set in the sight during orientation. The vertical gunpointer raises his horizon-

tal cross hair far enough above the target to allow for superelevation. The lateral gunpointer tracks off the target the estimated number of target lengths. Both gunpointers observe the splash and make corrections based on the sensing. If the speed ring sights are oriented for antiaircraft fire, the vertical gunpointer must allow for the superelevation set in the sight during orientation.

c. **Computing sights.** It is not practical to take superelevation out of the computing sight for ground fire. While speed ring sights are more desirable, it may be necessary to use the computing sight for ground fire. For a terrestrial mission, the sight is zeroed in speed. The vertical tracker must remember that superelevation is in the sight and may require tracking below the target to allow for that superelevation. The lateral tracker tracks off the estimated number of target lengths. Both trackers observe the splash and make corrections based on the sensings.

d. **Director.** When the director is used for ground fire, zero deflection and use direct tracking. The vertical tracker tracks off enough to provide for superelevation. The lateral tracker tracks off the estimated number of target lengths. Both trackers observe the splash and make corrections based on the sensing.

231. ADJUSTMENT OF FIRE. The adjustment of fire against ground or naval targets is based on splash, tracer, or burst sensings. Each round is sensed and corrections applied before firing again. In elevation, if the round is sensed as one target

height above the target, the elevation tracker moves the horizontal element of his sight down one target height. In azimuth, if the round appears one target length astern, the azimuth tracker moves the vertical element of his sight one more target length ahead.

CHAPTER 19

FIRE AT STATIONARY TARGETS

Section I. GENERAL

232. GENERAL. ***a.*** The problem of firing at stationary targets is much simpler than that of firing at aircraft. However, there are certain fundamental procedures that must be followed in order to obtain the most effective fire.

b. Automatic weapons will be employed against stationary targets when in the surface mission. The normal target will be machine-gun emplacements, mortars, light antitank guns, or something similar.

c. Automatic weapons fire is affected by nonstandard ballistic conditions, but at the normal ranges this effect is negligible and not considered.

d. All antiaircraft automatic weapons have some backlash in the azimuth and elevation gear trains. To counteract this, it is necessary to approach the azimuth and elevation settings from the same direction for any one target. Unless this is done the small amount of backlash present will nullify the corrections applied.

233. DETERMINATION OF FIRING DATA. ***a.* Direction.** The direction of the target with respect to

the gun is a fundamental element of data. This direction is obtained by placing the sight on the target in azimuth. Since the sight is set parallel to the gun bore, this automatically positions the gun in the proper direction.

b. Range. The second fundamental element of data needed is the range from the gun to the target. The setting of the gun in elevation is dependent mainly upon range. Range can be determined by the following methods which are listed in the order of decreasing accuracy:

(1) Survey.

(2) Range finder.

(3) Map.

(4) Air photograph.

(5) Estimation.

Dependent on the equipment and time available when the data are needed, the most accurate method for obtaining the range should be used.

c. Angle of site. The angle of site is the vertical angle between the gun-target line and the horizontal (fig. 68). This is the basic angle to be considered in setting the gun in elevation. The angle of site is determined by placing the sights on the target and, if desired, measuring the angle of site with a gunner's quadrant.

234. SUPERELEVATION. The superelevation angle is the vertical angle between the gun-target line and the axis of the gun bore (fig. 68). This angle allows for the curvature of the trajector during the time of flight. The superelevation needed de-

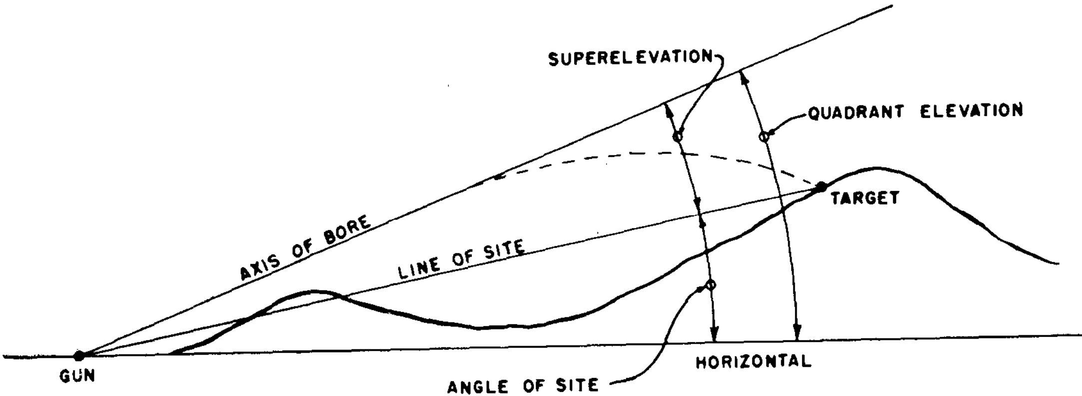


Figure 68. Elements of data.

pends on the slant range and elevation of the target; it is obtained from the appropriate firing tables. The superelevation needed for the 40-mm gun and the caliber .50 machine gun also can be computed rapidly with reasonable accuracy by means of the following expression:

$$\phi_s \text{ cal } .50 = 7 \ (D')^2$$

235. QUADRANT ELEVATION. The quadrant elevation is the vertical angle between the axis of the gun bore and the horizontal (fig. 68). The magnitude of this angle in the algebraic sum of the angle of site and the superelevation angle. If the angle of site is negative, it is subtracted from the superelevation angle, and if it is positive, it is added to it. The quadrant elevation is set on the gun with a gunner's quadrant, an elevation scale on the gun, or by use of the sight.

236. MINIMUM ANGLE OF ELEVATION. a. The minimum angle of elevation is the lowest elevation at which the guns can be laid and have the projectile clear a mask or friendly troops in front of the gun.

b. To obtain the mask clearance, three items must be determined:

(1) Angle of site to the mask.

(2) Superelevation corresponding to the range to the mask.

(3) Two "*c's*" at the gun for the mask range.

The first two items can be determined as previously mentioned. A "*c*" is the change in elevation needed to change the range 100 yards. The third item then is the change in elevation needed to in-

crease the range 200 yards at the mask. After the three items are determined, they are added algebraically to obtain the minimum angle of elevation needed to clear the mask.

c. When friendly troops are present between the gun and the target, the minimum angle of elevation consists of the three items in **b** above calculated for the troops' position and an additional item equal to the angle subtended by 5 yards at the troop range. The value of this angle is determined by use of the mil rule ($\text{m̸} = W/R$ where W equals width in yards and R equals range in thousands of yards), and is added to the minimum angle as determined in **b** above.

d. Tables 2 and 3 of FT 0.50 H–1 provide a means for determining the minimum angles of elevation for the caliber .50 machine gun. For the 40-mm gun it is necessary to determine each item separately, using the firing tables to obtain the values of superelevation and "*c's*". For the 40-mm gun, the zero angular height column Part Ie, FT 40 AA–A–2, is used. Since the range is graduated every 100 yards, the value of a "*c*" is readily determined.

237. EFFECT OF MINIMUM ANGLES OF ELEVATION. **a.** The minimum angles of elevation greatly affect the fields of fire of antiaircraft automatic weapons. This is due to the flat trajectory of the weapons.

b. If there is a mask 10 yards high and 500 yards from a 40-mm gun, the minimum angle of elevation is 25.1 mils. This means that the round will fall at 2,400 yards range, thus causing a 1,900-

yard dead area in which fire cannot be delivered. If the gun is placed 1,000 yards from this same mask, the minimum elevation is 19.5 mils. This elevation corresponds to a range of 2,050 yards, and the dead area is now 1,050 yards. If the gun were 2,000 yards from the mask, the dead area would be only 500 yards.

c. The flat trajectory thus influences the emplacing of the gun. The field of fire is selected and the gun so emplaced that it can deliver fire into it. The minimum angles of elevation must be considered in all cases.

238. MODIFICATIONS OF EQUIPMENT. a. In order to fire the guns at stationary targets, especially during periods of limited visibility, it is necessary to make some modifications of the present equipment. These modifications consist of placing indicators on the guns which allow the gun to be set in azimuth and, in some instances, in elevation.

b. Azimuth indicators may be placed on the base of the gun mount or on the azimuth handwheels. The position for azimuth indicators on each type of antiaircraft automatic weapons is as follows:

(1) *40-mm gun.*

(*a*) On the 40-mm gun an index mark is painted on the fixed portion of the lower carriage near the rotating portion of the upper carriage. On the upper carriage as near the index mark as possible, an azimuth scale is painted at 5-mil intervals for 6,400 mils.

(*b*) An azimuth indicator also is constructed on the azimuth handwheel of the 40-mm gun. The index mark is set on the azimuth gear box adjacent to the rotating portion of the azimuth handwheel. The scale then is fixed to the rotating portion of the handwheel and graduated for every 2 to 5 mils of change in azimuth, depending on the gear ratio of the gun.

(2) *Multiple machine-gun mount M45.* On the M45 mount, an index mark is painted on the top edge of the base. An azimuth scale at 5-mil intervals for 6,400 mils is painted on the rotating portion of the mount as near the index mark as possible.

(3) *Twin 40-mm gun motor carriage M19.* An azimuth indicator is constructed on the azimuth handwheel for the M19 mount similar to the one on the 40-mm gun.

c. Elevation indicators are placed on the handwheels of the 40-mm gun and M19 mount. They are graduated every 2 mils and are constructed similarly to the azimuth handwheel indicators.

Section II. TECHNIQUE OF FIRE

239. FUNDAMENTAL FIRE CONTROL PROCEDURE. a. Target designation. For prompt delivery of fire the target must be designated accurately. A target is designated by oral description, use of a range card,

thrust line on a map, or by firing smoke or similar type signal in the vicinity of the target.

(1) When a target is designated orally, the designation includes range, direction, and description of the target, in that order. Oral designations normally will be sufficient where direct fire is used. In this case, the range usually is estimated, the direction is relative to other terrain features, and the target description is only enough to distinguish it.

(2) Range cards should be made for each gun, whenever possible. A north line is drawn to permit rapid orientation of the card. These cards show the prominent terrain features and possible targets, with the direction and range of each indicated thereon.

(3) When the thrust line is used to designate a target, the coordinates are determined and given to the gun position where a similar map with thrust line is available.

(4) Targets can be designated by firing a mortar smoke shell near the target. The guns use the burst of the shell as an aiming point. Any type weapon can be used to point out the target, but it is desirable to use the type that will clearly show the vicinity of the target.

b. Laying in azimuth. To lay the gun in azimuth the azimuth sight of the gun is set on the target.

c. Laying in elevation. The gun can be laid in elevation by several means, depending upon the sighting system and the range to the target. The two basic elements which must be solved, regardless of the method of setting elevation, are the angle of site and superelevation angle. The manner in which these angles are set with the speed ring and computing sights follows.

(1) *Speed ring sights.*

(*a*) When it is necessary to bring fire to bear on a target very rapidly, the elevation is set by tracking off in the sight. The azimuth and elevation trackers set the vertical and horizontal cross hairs of the sights on the target. The elevation tracker then tracks off the estimated amount to apply the proper superelevation to the gun bore. Laying in elevation in this manner is approximate; it is used only when time does not allow greater accuracy and the target's range does not exceed 1,500 yards.

(*b*) When time permits, the gun is laid in elevation by means of the gunner's quadrant. The angle of site is determined by sighting on the target, as when orienting the sights, and then measuring the angle that the guns are elevated. Using the previously determined range, the superelevation is obtained from the firing tables or by calculation. The angle of site and the

superelevation angle are added, algebraically, to obtain the quadrant elevation. The gun then is set at this elevation by means of a gunner's quadrant. The azimuth tracker tracks on the target as previously described.

(2) *Computing sights.*

(*a*) When it is necessary to bring fire to bear rapidly on a ground target, the elevation tracker tracks off in his sight. This track off usually is necessary because the superelevation generated by the sight is based on angular height instead of range; the direction of track off is determined by the range to the target. As a guide to the amount of track off, the angular distance from the main cross hairs to the pip on the M24 reflex sight is equal to 9 mils. This method for setting elevation should not be used for ranges beyond 1,500 yards.

(*b*) The elevation can be set with a gunner's quadrant as with the speed ring sights. The deflection box is placed in the bore-sighting position with the speed dial at zero. The elevation tracker places the horizontal cross hair on the target and the angle of site is determined by measuring the angle of elevation of the gun. The superelevation angle is determined and added al-

gebraically to the angle of site. The quadrant elevation then is set on the gun by using the gunner's quadrant.

240. ADJUSTMENT OF FIRE. Fire is adjusted by means of tracer, splash, or burst sensings. The method by which the corrections are applied to the gun depends on the method of fire control being employed.

a. When the gun is laid by tracking off in the sights, the corrections are applied by further tracking off. The azimuth tracker traverses the gun the amount needed for the deviation to the right or left of the target. If the round appeared to the right of the vertical wire, the tracker moves the gun left until the target is the same position to the right of the vertical wire as was the round. In elevation the tracker must estimate the vertical correction needed and move the gun up or down. A common fault at ranges beyond 1,000 yards is to undercorrect in elevation. It is best to apply a bold correction in elevation and obtain a bracket.

b. Corrections are based on the sensings; the initial corrections should be bold in order to obtain a bracket. At ranges beyond 1,500 yards, the deviations should be spotted with binoculars. To determine the amount of correction needed, the value of "*c*" for the target's range should be determined from the appropriate firing tables. If the round is 50 yards short, the gun should be elevated one "*c*". When a bracket has been obtained the correction then is split. The azimuth tracker tracks off as before.

c. When the 40-mm gun is equipped with handwheel scales, they can be used to apply corrections rapidly by moving the handwheels the desired number of mils.

CHAPTER 20

TRACER OBSERVATION

Section I. GENERAL

241. GENERAL. All automatic weapons use tracer ammunition for adjustment of fire. Tracer observation is an aid in adjusting fire when using any of the present type of sights; however, some of the sighting systems require more dependence in tracer observation than others do. It is the purpose of this chapter to point out the capabilities and limitations of tracer observation and to indicate how each type of sighting system employs the use of tracers.

242. DEFINITIONS. The following definitions are standard nomenclature in tracer observation:

a. Cone of sight. If lines are drawn from the boundaries of the target to the observer's eye (here considered the pintle center of the gun), they will form a general cone. This is the *cone of sight* (fig. 69).

b. Slant pyramid. As the target sweeps out a band of finite depth (course band) in going from T_o to T_p the *cone of sight* generates the *slant pyramid.* As the midpoint range of the target becomes smaller, the cone, as well as the pyramid, becomes

thicker, and the aiming tolerance required to get a *cone of sight* (or line) shot becomes greater. If the midpoint range is great, the *cone of sight* approaches the line of sight, the course band approaches the course line, and the *slant pyramid* approaches the slant plane (fig. 69).

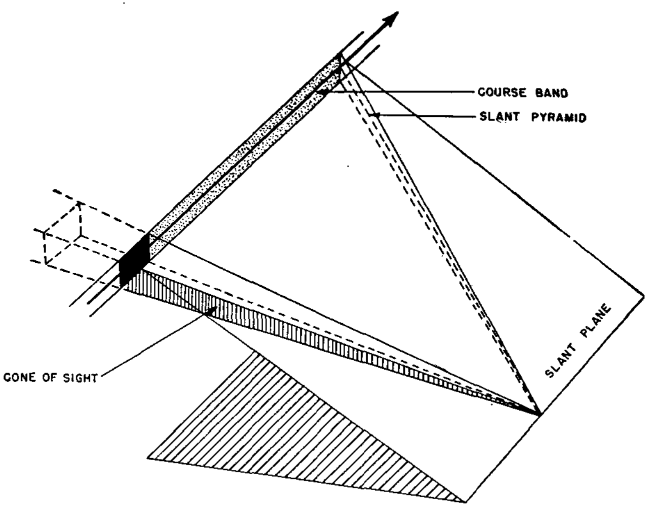


Figure 69. Cone of sight.

c. Line shot. The line of sight shot, or "line" shot is any shot that pierces the cone of sight. This definition requires that the apex of the cone be at the pintle center of the gun. *Thus the observer must be in the slant plane to see line shots;* the best position for the observer then is at the gun.

d. Ahead. This term is used to describe the tracer when it passes in front of the target; that is, the shot had too much lead.

e. Astern. This term is used to describe a tracer that passes in rear of the target; that is, the shot had too little lead.

f. High. This term is used to describe a tracer that passes above the target.

g. Low. This term is used to describe a tracer that passes below the target.

h. Right. This term is used when, on an incoming or outgoing course, the tracer passes to the right of the target.

i. Left. This term is used when, on an incoming or outgoing course, the tracer passes to the left of the target.

j. Silhouette. When a line shot passes astern of the target, the tracer is silhouetted against the target. This condition is known as a silhouette and

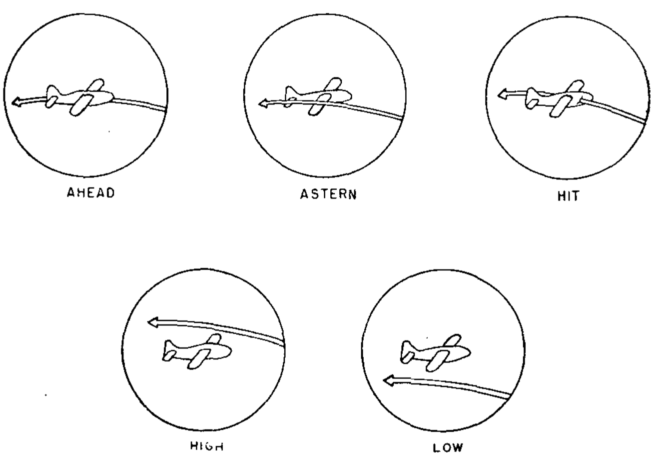


Figure 70. Observation of fire.

indicates that the shot is a line shot with too little lead (fig. 70).

k. Eclipse. When a line shot passes ahead of the target, the target eclipses the tracer. This condition is known as an eclipse and indicates that the shot is a line shot with too much lead (fig. 70).

243. INFORMATION DESIRED FROM TRACER OBSERVATION. a. Tracking information, gunnery link number 1.

b. Slant plane information, gunnery link number 2.

c. Lead information, gunnery link number 3.

244 INFORMATION AVAILABLE FROM TRACER OBSERVATION. a. When using a computing sight, erratic tracking can be seen when the tracers move in and out of the slant plane continuously throughout a rectilinear course without a change in the course arrow position. Erratic tracking is evident when the tracers stay in the slant plane, but hits or fly-throughs occur with improper progression of tracer sensings. For example, when using the computing sight and firing on the approaching leg of a level course, the tracers should progress from astern to ahead; therefore, if the tracers appear to progress from ahead to astern, with no change in speed setting to justify this progression, the tracking is erratic.

b. The gunner cannot determine from tracer observation what his error in aiming is *now*.

c. The tracer information he receives is always stale. It pertains to shots fired "time-of-flight" seconds ago. If a 40-mm gun is firing at a target 1,500 yards away, time-of-flight delay is 2 seconds and the gunner knows what his error in aiming was 2 seconds previously.

d. The gunner can tell whether or not he is firing in the slant plane and, under favorable conditions, whether his lead is too large or too small. In general, he cannot tell *how much* his lead is in error.

245. SLANT PLANE INFORMATION. a. Slant plane information is valuable even though it is stale by "time-of-flight" seconds, because, for a plane flying a straight course, the slant plane once established remains the same.

b. The gunner is in an ideal position to observe line shots. In order to see line shots, an observer's eye must be in the slant plane and the only practical location, which puts his eye in the slant plane, is at the gun.

c. For observers at the gun, line shots are easy to identify. If the shots are not in the slant plane, it also is easy to see how the shooting plane must be moved to bring the shots in the slant plane.

d. A given tracer may not be in the slant plane, indicating that the shooting plane was not in the slant plane "time-of-flight" seconds ago. On crossing courses, such a shot may be "high" or "low". On incoming courses, the tracer may be "right" or "left."

246. LEAD INFORMATION. a. In antiaircraft gunnery, the gunner's eye follows a moving target silhouetted against a formless sky. Because there are no stationary reference points in his field of view, the gunner tends to be unaware of the target's motion. When tracers appear in the vicinity of the target, the gunner sees them moving parallel to the target's path and opposite to the target's real motion. Actually, the tracers are moving straight away from him, but he sees the result of relative motion of target and tracers perpendicular to his line of sight. On some parts of the target's path of flight the tracers appear to curve sharply and to cut back to the target and, almost invariably, the gunner receives the impression that his lead is greater than it actually is. If the gunner had perfect depth perception, he would be able to compare the range of the target with the range of the tracer at any instant; thus he would know the status of his lead without depending on line shots. However, the gunner does not have depth perception all the way out to the target. After the tracer passes the limits of his depth perception, the gunner loses his ability to judge the tracer's range. He might think that the tracer is at the target range, but he has no way of telling where the tracer is in reference to range. The only way to find lead information is to get a line shot. To call a tracer ahead or astern without a line shot *is sheer folly.*

b. As the range increases, visibility of tracers and aiming tolerance decrease. As aiming tolerance decreases, it becomes more difficult to get line

shots. Line shots are necessary if the gunner is to get lead information.

247. OBSERVATION OF TRACERS. a. Previously, it has been mentioned that the tracers usually appear to curve sharply and to cut back to the target. This apparent tracer curvature creates baffling illusions to the gunner. It is fundamental, therefore, in the observation of tracers that the gunner eliminate the tracer path from the gun to the target from his vision. He must localize his field of vision to the immediate vicinity of the target and thereby disregard all curvature of the tracer stream. By superimposing the picture of the tracer in the vicinity of the target upon the picture of the target, the gunner makes his sensings. Successful tracer observation depends upon this principle of superimposition.

b. For training purposes only, it is possible to sense each tracer for lead without line shots by positioning an observer down course. Thus it is possible to make round for round analysis of any target engagement.

c. With respect to the down course observer, the projectile has a motion perpendicular to the observer's line of sight. At a certain point on the trajectory, the rate of perpendicular motion of the projectile to the line of sight will be equal to the rate of motion of the observer's line of sight itself. When this condition occurs, since the target is taken as a reference point, the projectile appears to stay at the same distance from the target for an appreciable length of time. The effect of this is

to form a definite "hump" in the tracer path. The position for the observer can be chosen for any course so that the "hump" will appear when the tracer is at approximately the same range (with respect to the observer) as the target. Thus the observer can get a definite indication as to errors in lead. In order that the "hump" will appear at the proper place, the observer must be located on the *down* course flank and nearly in the slant plane. Thus, for a level course, he must be near a line passing through the pintle of the gun and parallel to the target's course. The distance from the gun depends on angle of approach, target speed, and slant range. However, a general equation can be given for an approximately correct position in terms of speed and midpoint slant range.

$$\frac{b = 2S\ D_m}{1{,}000}$$

in which b is the distance from the gun in yards, S is the target speed in yards per second, and D_m is the minimum slant range.

d. An observer located at distance b from the gun will see all *asterns* as continuously astern of the target. All *aheads* will pass ahead of the target at some point on the trajectory. Hits will appear to "hump" at the target since the hump occurs at the same range as the target. With down course spotting it is not necessary to obtain line shots to determine errors in lead. A shot having correct lead, but below the slant plane, will appear to "hump" directly below the target.

248. BASIC GUIDES IN TRACER OBSERVATION. a. The gunner must keep his eye on the target and observe tracer streaks in the vicinity of the target.

b. Tracer information is always stale. It can only tell the gunner how he was doing "time-of-flight" seconds ago.

c. Line shots can be identified very easily if the observer is in the slant plane and at the gun.

Section II. USE OF TRACER OBSERVATION AS AN AID TO OTHER FIRE CONTROL METHODS

249. GENERAL. Regardless of the type of sighting system used, the observer will get about the same information from his observation. However, some methods of fire control depend more on tracers than do others. The most common error is to depend upon tracers entirely at the expense of fundamental knowledge of gunnery. This section will attempt to point out the use of tracer information as an aid to three general types of fire control presently in use.

250. SPEED RING SIGHTS. Speed ring sights are designed to be operated without dependence on tracer observation. Nevertheless, if a positive tracer sensing is obtained, the gunner will use it. Certainly if the tracers appear high, the gunner would be disregarding valuable information if he did not depress the muzzle of the gun. However, the gunner must not rely upon tracer, but should track with the proper sight picture at all times. Hits will result if proper procedure is followed.

251. COMPUTING SIGHTS. Computing sights are almost entirely dependent upon tracer observation for effective shooting. Rarely does the lead setter position the course arrow correctly without at least one adjustment during firing; yet the only means of determining whether line shots are being obtained is by tracer observation. The only positive knowledge of lead comes from reading the line shots. Therefore, it is impossible to adjust for line or lead without observing tracers.

252. DIRECTORS. a. The least dependent of all the types of fire control on tracer is the director (M5A2 or M5A3). With properly oriented and leveled equipment, the director insures line shots if the tracking is smooth and accurate. The use of the coincidence range finder provides for fairly accurate present position ranges and the proper use of the range "spot" will provide for fly-throughs. The proper use of the director and a firm knowledge of the gunnery factors involved in that equipment will do more to insure hits than observation of tracers.

b. However, tracers can be of use if they are properly evaluated. In the training phase, tracers will indicate if the tracking is smooth and if line shots are being obtained. They also can show if fly-throughs are being obtained.

APPENDIX I

REFERENCES

SR 310–20–3	Index of Army Training Publications.
SR 110–1–1	Index of Army Motion Pictures and Film Strips.
FM 21–8	Military Training Aids.
TM 20–205	Dictionary of United States Army Terms.
FM 44–8	Antiaircraft Operations Room and Antiaircraft Artillery Intelligence Service.
FM 44–57	Service of the Piece, Multiple Machine Gun Mounts.
FM 44–60	Service of the Piece, 40-mm Fire Unit.
FM 44–62	Service of the Piece, Twin 40-mm Gun Motor Carriage M19.
FM 6–40	Field Artillery Gunnery.
FM 7–15	Heavy Weapons Company, Rifle Regiment.
FM 7–20	Infantry Battalion.
FM 7–40	Rifle Regiment.
FM 31–50	Attack on a Fortified Position and Combat in Towns.
FM 100–5	Operations.

APPENDIX II

GLOSSARY OF AUTOMATIC WEAPONS TERMS

Ahead—A shot which passes in front of the target, with reference to the course line. A line shot which is ahead will later be observed as an eclipse.

Angle of approach—The angle, not greater than 180°, measured between G, T_o, and T_p.

Angular height—The vertical angle between a specific line and the horizontal plane.

Approaching leg—That portion of the target's course line in which the slant range decreases for successive positions.

Astern—A shot which passes to the rear of the target, with reference to the course line. A line shot which is observed as a silhouette will later be astern.

Center of mass—That point which represents the mean position of the matter in a given target.

Climbing course—A course in which the altitude is increasing.

Cone of sight—A general cone formed by elements radiating from the sight operator's eye to the

outer boundaries of the target. If the target were a point, the cone of sight and the line of sight would be the same thing.

Course line—The extension of the line T_o T_p indefinitely both ahead and astern of the target. The target course line is the same as the target path when the target moves in a straight line.

Crossing course—Any course not incoming or outgoing.

Directly at the gun—A course in which the target is flying toward the pintle center of the gun.

Diving course—A course in which the altitude is decreasing.

Eclipse—The appearance of the tracer streak relative to the target during the time interval in which the projectile pierces the cone of sight at a slant range greater than that of the target. It occurs when the tracer streak is beyond the target, with the target in the foreground.

Fly-through—The act of the target passing through the cone of fire. During the fly-through the generated lead equals the required lead.

Fly-through time interval—The lapse of time measured in seconds for the fly-through to occur.

Future position of the target—The point on the course line where a properly aimed round fired with the target in the present position would hit.

Generated lead angle—The angle between the line of sight and the axis of the gun bore, disregarding superelevation.

Gunnery chain—A teaching concept, used in referring to the four gunnery conditions which must be satisfied to get a hit. It is an imaginary chain of four links, supporting a weight which represents a hit.

High—A tracer that passes above the target.

Horizontal plane—The plane containing the pintle center of the gun and all points at that same elevation, assuming no curvature of the earth.

Incoming course—A course in which the target is flying toward the gun ($\Sigma_s = 90°$).

Level course—A course in which the target is flying at a constant altitude.

Line shot—Any shot that pierces the cone of sight.

Line of future position—The line from the gun to the future position of the target.

Low—A tracer that passes below the target.

Midpoint—That point along the course line at minimum range to the gun.

Outgoing course—A course in which the target is flying away from the gun ($\Sigma_s = 90°$).

Pintle center of the gun—The point of intersection of the vertical and horizontal axes of the gun bore.

Present position of the target—The position of the target at the instant a round is fired.

Quadrant elevation—The vertical angle between the axis of the gun bore and the horizontal plane.

Receding leg—That portion of the target's course line in which the slant range increases for successive positions.

Required lead angle—The angle between the line of sight and the line of future position.

Silhouette—When a line shot passes astern of the target, the tracer is silhouetted against the target. This condition is known as a silhouette and indicates that the shot is a line shot with too little lead.

Sight reference axis—A line perpendicular to the intersection of the cross hairs or the center of the concentric rings of a sight. When a sighting device is oriented (no lead in the sight) for antiaircraft fire, the sight reference axis is parallel to the gun bore, disregarding superelevation.

Slant plane—That plane containing the target course line and the pintle center of the gun.

Slant plane angular height—The dihedral angle between the slant plane and the horizontal plane.

Slant range—The distance, in yards, from the gun to a specific point on the target course line.

Shooting plane—That plane containing the line of sight and the axis of the gun bore, disregarding superelevation.

Superelevation angle — The angle of elevation placed on the gun to compensate for the curvature of the trajectory.

Target path—The line generated by the target's center of mass as the target moves. The target path is the same as the target course line only when the target moves in a straight line.

Target speed—The speed of the target along its course line.

Time of flight—Time, in seconds, required for the projectile to travel a certain range.

Tracer control—The art of controlling fire based solely on information obtained from tracer observation.

Tracer observation—The technique involved in determining the location of a projectile, relative to a target, by observing the location of a tracer streak relative to the target.

Tracer sensing—A decision as to location of a projectile relative to the target, obtained through tracer observation.

APPENDIX III

ESTIMATES, PLANS, AND OPERATION ORDERS

Section I. ESTIMATES AND PLANS

1. GENERAL. Every military operation should have a definite aim. A commander's decision requires a definite course of action in meeting the situation which confronts his command. The course of action adopted must result from a sound decision, and this sound decision is necessarily a result of a timely and proper estimate of the situation.

2. PURPOSE. The purpose of the estimate is to insure that the commander will give due consideration to all factors of the situation, including enemy capabilities, so that he may adopt a course of action which—

a. Favors the accomplishment of the mission.

b. Offers the best prospects of success.

3. ELEMENTS OF THE ESTIMATE. Following is the five-paragraph form for preparing the estimate of the situation.

Paragraph 1. MISSION. A statement of the task and its purpose. If the mission is multiple, priorities are determined. If there are intermediate tasks, prescribed or deduced, such tasks are listed in this paragraph.

Paragraph 2. THE SITUATION AND COURSE OF ACTION.

a. Considerations affecting the possible source of action. Determine and analyze those factors of the situation which will influence the choice of a course of action.

(1) Characteristics of the area of operations including weather, terrain, hydrography, and communication, as well as politics, economics, and sociology.

(2) Relative combat power including enemy and friendly strength, composition, disposition, and status of supply, reinforcements, morale, and training.

b. Enemy capabilities. Note all the possible courses of action within the capabilities of the enemy which will affect the accomplishment of the mission.

c. Own courses of action. Note all practicable courses of action open which if successful will accomplish the mission.

Paragraph 3. ANALYSIS OF OPPOSING COURSE OF ACTION. Determine the probable effect of each enemy capability on the success of each course of action considered.

Paragraph 4. COMPARISON OF OWN COURSES OF ACTION. Weigh the advantages and disadvantages of each course of action considered and decide which course of action promises to be the most successful in accomplishing the mission.

Paragraph 5. DECISION. Translate the course of action selected into a concise statement of what the force as a whole is to do, and so much of the elements of when, where, how, and why, as may be appropriate.

4. THE ESTIMATE A CONTINUOUS PROCESS. Since the situation is continually changing, the estimate also must be changed to keep pace with the situation. As the commander receives new orders and intelligence from higher headquarters, he must revise his plans and make new decisions.

5. REFERENCES. For more complete information on this subject, see FM 101–5.

Section II. OPERATION ORDERS

6. GENERAL. This section is intended as an aid in preparing a battalion operation order. In operation orders from headquarters, information concerning the antiaircraft artillery is contained in paragraph 3. It is from this paragraph that the commander compiles the information that is to make up his order.

7. FORM FOR OPERATION ORDER. Following is the five-paragraph form for preparing operation orders.

Paragraph 1. GENERAL SITUATION. Such information of the general over-all situation as may be essential for subordinates to understand the current situation.

a. Enemy forces. Composition, disposition, location, movements, estimated strengths, identifications, and capabilities.

b. Friendly forces. Pertinent information of own forces other than that listed in the Task Organization which may have a bearing on the decision of a subordinate.

Paragraph 2. MISSION. A statement of the task which is to be accomplished by the commander and its purpose.

Paragraph 3. TASK FOR SUBORDINATE UNITS. In separate lettered subparagraphs, give the specific tasks of each element of the command charged with the execution of tactical duties.

x. In subparagraph *x*, give instructions applicable to two or more units or elements, or to the entire command, which are necessary for coordination or the general conduct of the operation.

Paragraph 4. ADMINISTRATIVE AND LOGISTICAL MATTERS. Broad instructions concerning administration and logistics for the conduct of the operation. This information frequently is included in the annex or separate document; in this case, the paragraph makes proper reference to the annex or document.

Paragraph 5. COMMAND AND SIGNAL MATTERS. Plan of communication (reference to standard plan or in annex), zone, time to be used, rendezvous, location of commander and command posts, statement of command relationships, and axis of signal communication, as appropriate.

APPENDIX IV

AUTOMATIC WEAPONS TRAINING AIDS

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1. TRACKING MAZE FOR POWER MOUNTS. **a.** A tracking maze is a complicated path drawn in geometric shapes. The pattern of a maze can be given many variations, but should contain straight lines at varying angles, varying curves, and one or two complicated figures. Sharp corners or breaks in curvature must be avoided. The maze should contain curves which require tracking motion that simulates tracking the usual airplane courses. One-second intervals can be added at measured distances along the maze to indicate time intervals and thus control tracking rates. Close spacing produces slow speeds and open spacing produces fast speeds.

b. A tracking maze can be laid out on long sheets of wrapping paper and tacked to the walls of the buildings. This may be inside or outside; training facilities will determine the location. If the guns are to be 20 feet from the maze, the line tracing out the maze should be 1 inch wide. Various sections of the maze should not come closer to each other than 6 or 8 inches. Figure 71 is an example of a tracking maze.

2. CHECK SIGHTS. a. Training in tracking can be improved and supervision made easier if check sights are used. This sight can be any device so located that an instructor can observe without interfering with the tracker. On an M45 type mount, a Mark IX sight bracket can be inverted and the sight mounted. On a 40-mm gun there are many possibilities for check sight mounting.

b. If the check sight is to be of any value, it must be oriented accurately with the sights being used. On the matériel that has sights which are offset by the computing mechanism, the check

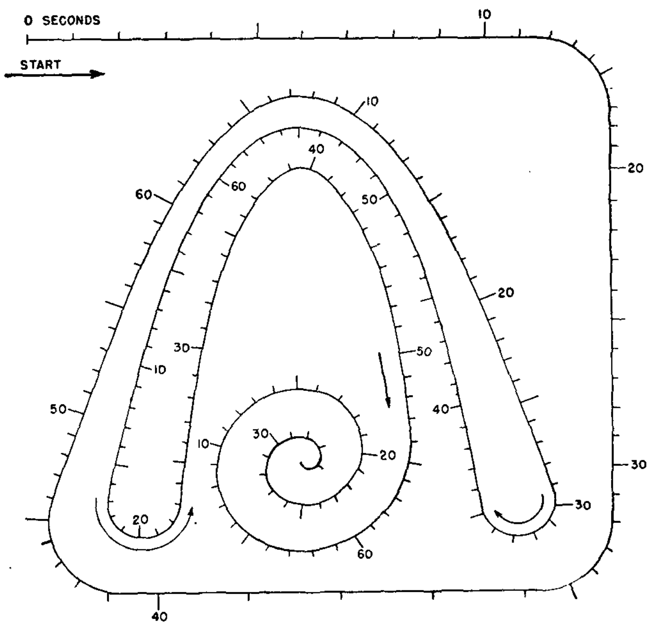


Figure 71. Tracking maze.

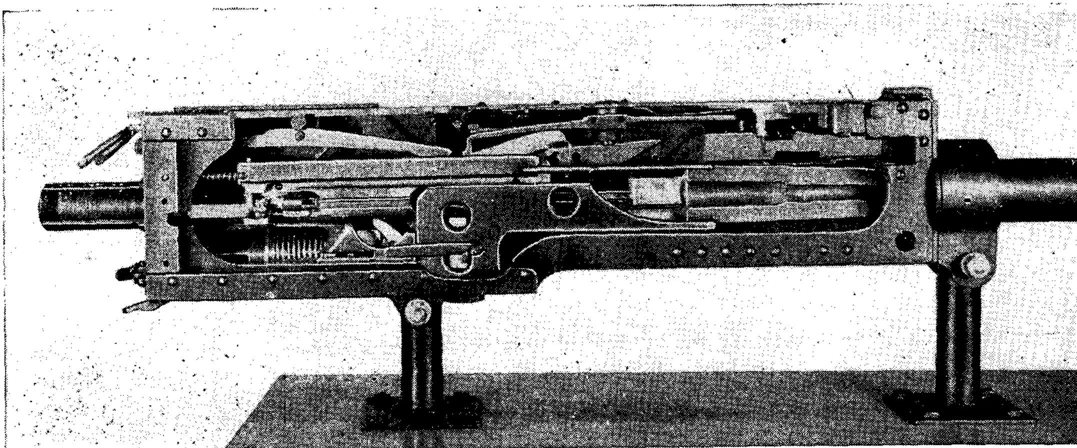


Figure 72. Training model, caliber .50 machine gun.

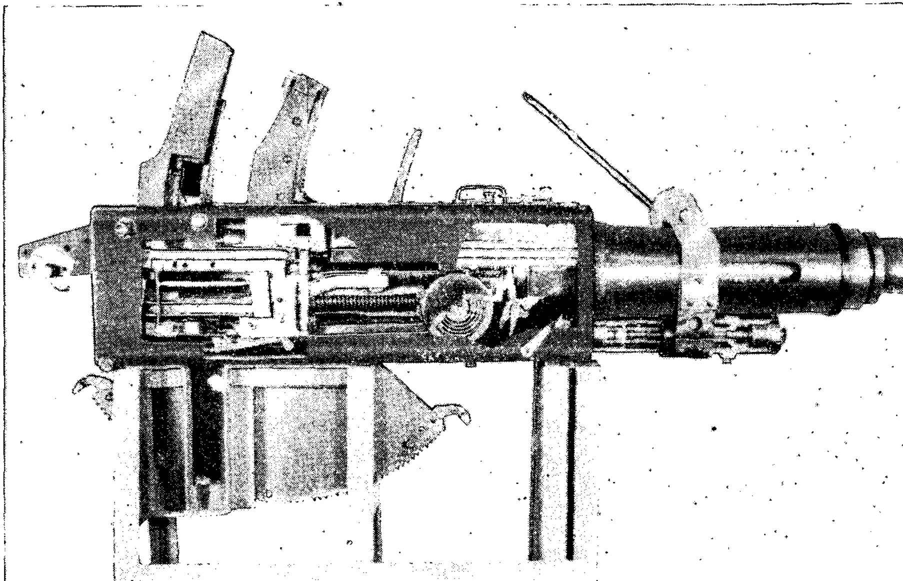


Figure 73. Training model, 40-mm gun.

sight must be mounted so that it, too, is offset a like amount.

3. TRAINING MODELS USED AT AAA SCHOOL. a. Caliber .50 machine gun. There is available a cutaway model of the caliber .50 machine gun. This model is constructed so that all the component parts can be seen in operation. The operation is by hand and is slow enough for each action to be observed (fig. 72).

b. 40-mm gun. A model of the 40-mm gun has been developed that will show in detail and in slow motion each operation of the weapon. The parts normally hidden are shown in this cutaway model. Dummy ammunition is used to show loading and firing action (fig. 73).

APPENDIX V

DETAILS OF DIRECTOR SOLUTION

1. GENERAL. The method whereby the gun is pointed in both azimuth and elevation may be separated into three main groupings—the solution of range by the range finder; the solution of firing data by the director proper; and finally the transmission of the firing data by the remote control system to the gun. These three steps are performed, to all intents and purposes, simultaneously.

2. SOLUTION OF RANGE AND TIME OF FLIGHT. *a.* The range adjuster sees two images of the target in the range finder. He slowly turns the altitude knob while looking at the target through the range finder until the images coincide. Turning the knob positions the altitude potentiometer brush, and a voltage equivalent to the number of yards altitude (H_o) on the altitude scale is sent into channel I of the amplifier (fig. 74). A voltage equivalent to D_o x sin ε_o, which is equal to H_o, is sent into channel I also. Any difference between the two input voltages will cause the amplifier to put out a voltage which runs the range finder servo motor. The range finder servo motor turns the brush on the range finder potentiometer and, at the same time,

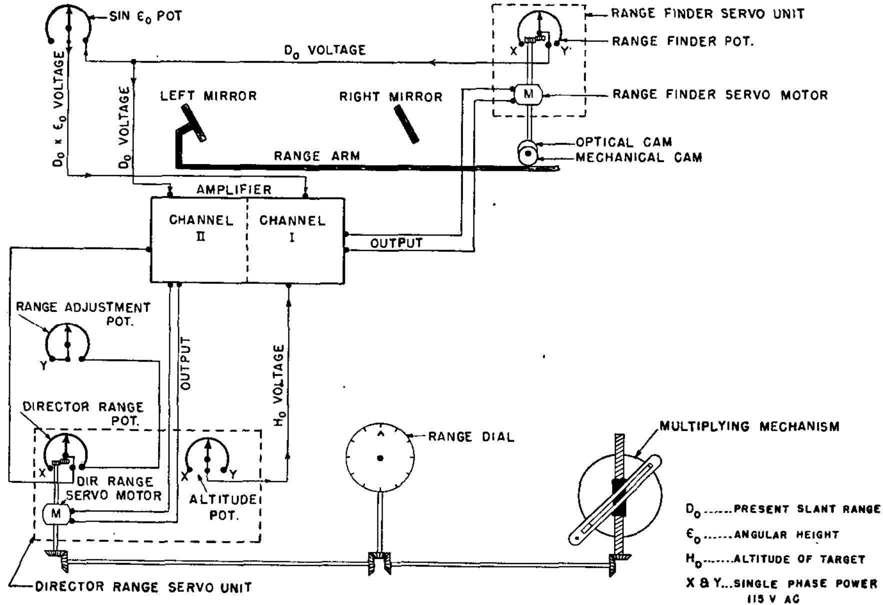


Figure 74. Schematic of the M10 range finder

turns the optical and mechanical cams. The mechanical cam, in turn, positions the left mirror in the range finder. The voltage from the brush of the range finder potentiometer represents present slant range and goes from the brush to one side of the sin ε_o potentiometer winding. Here the D_o voltage is multiplied by the voltage equivalent to the sine of the angular height of the target, and a voltage equivalent to D_o x sin ε_o or H_o is taken off the winding of the sin ε_o potentiometer by the brush and sent to channel I of the amplifier. When D_o x sin ε_o voltage reaches the same value as the H_o voltage, they cancel out and the output from channel I stops. The operator knows that he has set the correct H_o on the altitude potentiometer and that range has been solved when he sees the target in coincidence in the range finder.

b. In a level crossing course, the angular height and slant range to the target change continuously; however, through the action of the sin ε_o potentiometer, the target is automatically kept in coincidence. As the angular height of the target changes, the elevation tracker must elevate or depress the tracking telescope, which rotates the telescope shaft inside the director. Since the brush of the sin ε_o potentiometer is geared to the telescope shaft, the brush will be made to move to a position on the sin ε_o winding and pick off a voltage equivalent to the sine of the angular height of the target. This will cause a change in the voltage going into the amplifier from the brush of the sin ε_o and the balance of channel I is upset causing the amplifier to send an output to the range finder servo

motor. This causes the range finder servo motor to run and, thus gradually repositions the left mirror, keeping the target in coincidence; at the same time, it moves the brush of the range finder potentiometer to a new position where the voltage picked off the winding when multiplied by the sine of the new angular height will again equal the H_o voltage.

c. In order to get the present slant range into the director, another tap is taken off the range finder potentiometer brush and fed into channel II of the amplifier; this is also the D_o voltage representing slant range. A lead from the director range potentiometer brush is connected to channel II of the amplifier, thus giving another input. This voltage represents the range setting on the range dial and the position of the time nuts on the multiplying mechanisms. When the two inputs are not the same, channel II will send an output voltage to the director range servo motor causing it to run. This motor is geared to the brush of the director range potentiometer. The motor will run until it has repositioned the brush to a point where the voltage it picks off will equal the D_o voltage. When the two inputs are equal, the amplifier will stop the output and the motor will cease running. While the director range servo motor is positioning the director range potentiometer brush, it also sets the changing slant on the range dial and positions the time nuts on the multiplying mechanisms inside the director.

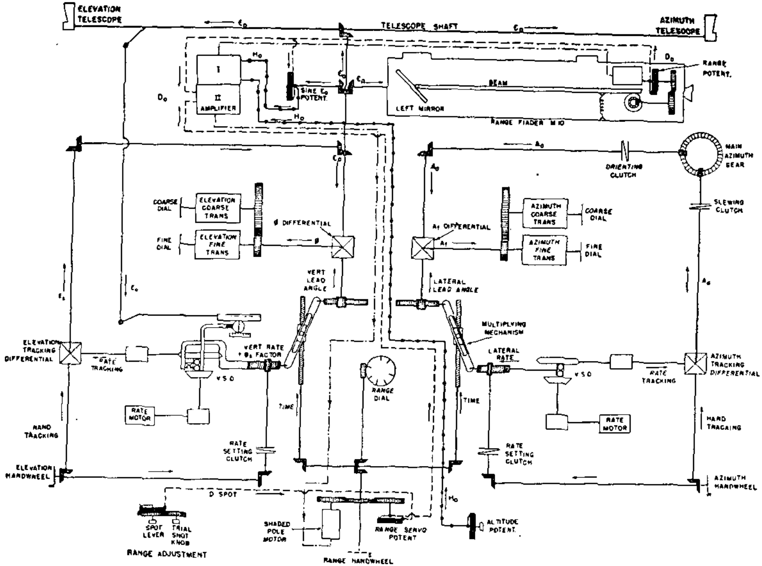
d. The range dial on the director is graduated nonuniformly; that is, the distance the indicator

moves for each change of 100 yards range is not the same. This dial actually is graduated in terms of time of flight with the range equivalent for these times of flight marked on the dial. The indicator moves a greater distance from 500 to 600 yards than it does from 600 to 700 yards. The greater the range, the smaller the distance the indicator moves for each 100 yards increase in range. Correspondingly, the time nuts on the multiplying mechanism will not move the same distance along the time screw for each change of 100 yards range. It will take more revolutions of the time screws to move the time nuts from 500 to 600 yards range than it would to move them from 600 to 700 yards range. The necessity for nonuniformity of range dial graduations and for nonuniform movement of the time nuts for equal increments of range is based on two factors—one, the nonuniform relationship between range and time of flight; and two, the basis of solution employed by the multiplying mechanisms. In order to take care of this, the director range potentiometer is specially wound so that it can properly govern the number of revolutions of the time screw for each 100 yards change in range. For example, the brush moves a greater distance along the potentiometer windings to match the change in D_o voltage from 500 to 600 yards than it does to match the change in D_o voltage from 600 to 700 yards. A voltage picked off the winding by the brush arm will produce a time of flight setting of the time nut in the multiplying mechanism of the director which is

equivalent to the present range (D_o) of the target as measured by the range finder.

e. The range adjustment potentiometer is connected in series with the director range potentiometer. Any movement of the range adjustment mechanism controls will vary the voltage in the circuit so that the potential coming off the director range potentiometer brush will upset the voltage balance in channel II. This causes the director range servo motor to run, repositioning the brush of the director range potentiometer until it again picks off a voltage equal to the D_o voltage coming from the range finder potentiometer brush. The result is a *PERCENT* change in the range dial setting and a corresponding change in the time nut setting on the multiplying mechanisms without affecting the range finder servo unit. This is the means by which fire adjustment is effected.

3. SOLUTION OF FIRING DATA. a. Azimuth. The azimuth tracker tracks the target with the rate setting clutch engaged and the constant speed motor switch on (fig. 75). A movement of the azimuth handwheel is transmitted by gears in two directions. One direction is toward the azimuth tracking differential; the other is toward the ball carriage of the variable speed drive. The ball carriage is offset an amount proportional to the azimuth angular rate at which the target is traveling. This offset causes a movement of the balls which is transmitted through the variable speed drive cylinder and gear reduction box to the tracking differential. In the tracking differential the man-



SCHEMATIC DIAGRAM. DIRECTOR. M5A2

Figure 75. Schematic of M5A3 director.

ual tracking rate and the variable speed drive tracking rate are combined to produce the actual azimuth angular rate of the target; this angular rate is transmitted to the main azimuth gear which traverses the director. The actual angular rate necessary to keep the director pointing at the target is present azimuth. A system of gears transmits this present azimuth to the firing azimuth differential. At the same time that present azimuth is being measured, the ball carriage is being offset from the center of the variable speed drive disc; this offset moves the link of the multiplying mechanism from the vertical position an amount equal to the ball carriage offset; this action introduces an azimuth rate into the multiplying mechanism. Time of flight, as converted from range in the range servo potentiometer, positions the time nut of the multiplying mechanism. The multiplication of angular rate by time of flight takes place and produces the azimuth lead angle which is transmitted through the deflection gear to the firing differential. The firing differential combines the lead angle with the azimuth of the present position of the target producing firing azimuth. Firing azimuth then is transmitted to the gun by the remote control system.

b. Elevation. The elevation tracker tracks the target with the rate setting clutch engaged and the constant speed motor switch on. A movement of the tracking handwheel is transmitted by gears in two directions. One direction is toward the ball carriage of the variable speed drive; the other is toward the tracking differential. The ball carriage

is offset from the center an amount proportional to the elevation angular rate at which the target is traveling. This offset causes a movement of the balls which is transmitted through the variable speed drive cylinder and gear reduction box to the tracking differential. In the tracking differential the manual tracking rate and the variable speed drive tracking rate are combined to produce the actual elevation angular rate of the target. This rate is transmitted through a system of gears to produce present angular height. This present angular height is transmitted to the elevation firing differential. In obtaining the elevation lead angle, superelevation must be taken into consideration. Since superelevation is a function of angular height and varies inversely with the angular height, the superelevation factor is set in by means of the superelevation cam and cam follower. The superelevation cam is connected to the elevation telescopes by means of a rod. As the angular height changes, the cam is rotated, thus moving the cam follower which offsets the ball carriage. As the tracker compensates for this offset, he sets in the superelevation. The combination of vertical or elevation rate and the superelevation factor then is sent to the multiplying mechanism. In the multiplying mechanism, the time of flight is multiplied by the combination of elevation rate and superelevation factor producing the total vertical lead angle. The elevation lead angle is transmitted by the deflection gear to the quadrant elevation differential where it is combined with the present angular height of the target to produce quadrant

elevation. The quadrant elevation then is transmitted to the gun by the remote control system.

4. TRANSMISSION OF FIRING DATA. (REMOTE CONTROL SYSTEM) **a.** To trace the flow of data from the director to the oil gear, this discussion is limited to the azimuth side of the director and gun. This explanation is applicable to the elevation data transmission system units also, since they operate in the same manner.

(1) When the main power plant switch is turned on, the data transmission system is energized with single phase 115-volt alternating current. This voltage energizes the director fine transmission rotor and the gun transmitter rotor. As power passes through the director fine transmitter rotor coil, a magnetic field is set up around the coil. For purposes of illustration, this magnetic field induces a voltage in the stator coil between terminals 1 and 3 (fig. 76). The voltage flows from the stator coil of the director fine transmitter between terminals 1 and 3 to the oil gear differential selsyn rotor. This sets up a magnetic field around the differential rotor coil between terminals 1 and 3. Voltage from the power plant passing through the rotor of the oil gear transmitting selsyn causes a magnetic field to build up around the rotor coil. This magnetic field induces a voltage in the stator coil between terminals 1 and

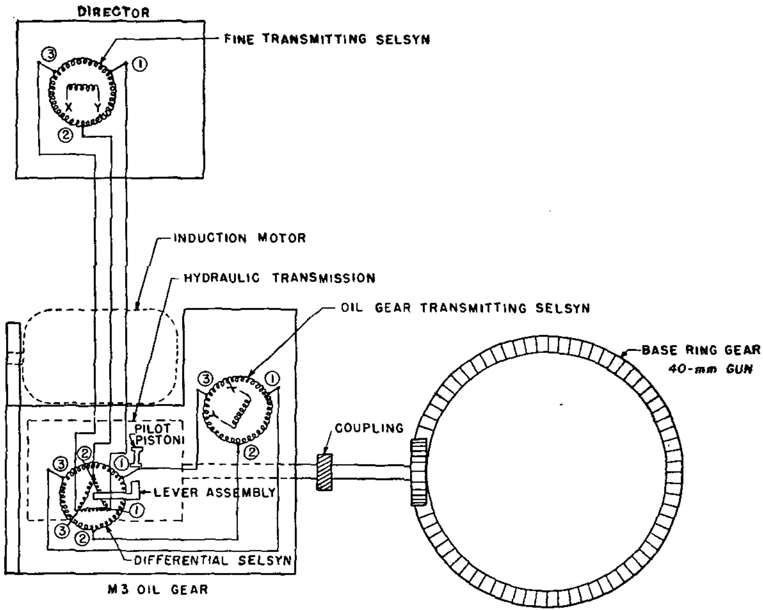


Figure 76. Remote control system.

2. This voltage flowing through gun transmitter stator coil between terminals 1 and 2 will flow through the stator coil of the oil gear differential selsyn between terminals 1 and 2. This builds up a magnetic field around the oil gear differential stator coil.

(2) An analysis of the conditions set up in the differential selsyn will aid in understanding the transmission system. First, a magnetic field has been established around the rotor coil between terminals 1 and 3; another magnetic field has been established around the differential selsyn stator coil between terminals 1 and 2. The action of the two magnetic fields established in the differential selsyn is a pulling force on each magnetic field. Because the stator of the differential selsyn cannot move, the magnetic attraction causes the rotor to turn. Mechanical stops limit the rotation of the rotor to no more than 8° from neutral position, in either a clockwise or counterclockwise direction.

(3) Under conditions as established above, figure 76 shows the rotor of the differential selsyn moving in a counterclockwise direction as a result of the force exerted by the two magnetic fields. Attached to the rotor of the differential selsyn is a lever assembly and pilot piston. The lever assembly moves as the rotor rotates; this, in turn, moves the pilot piston up.

When the pilot piston is displaced from the neutral position, it allows the hydraulic transmission to operate. A shaft attached to the hydraulic transmission is connected to the base ring gear of the 40-mm gun. Any rotation of the hydraulic transmission will be transmitted to the base ring gear of the gun and will cause the gun to traverse. The rotor of the oil gear transmitting selsyn is geared to the output shaft of the hydraulic transmission so that the rotor will move as the shaft rotates. When the oil gear transmitter rotor rotates an amount sufficient to cause the two magnetic fields in the differential selsyn to become balanced, an error corrector mechanism holds the pilot piston displaced as long as the director is traversing, allowing the hydraulic transmission to turn the gun.

b. (1) On the 40-mm gun there are two M3 oil gear units. One positions the gun in azimuth and the other positions the gun in elevation. These oil gears are controlled by coarse and fine transmitting selsyns in the director. The coarse transmitting selsyns are used only to make the gun and director self-synchronous. The fine transmitting selsyns control the output of the oil gears during normal tracking. This is accomplished with the aid of the differential selsyn and oil gear transmitting selsyn (fig. 76).

(2) The differential selsyn receives electrical inputs from the oil gear transmitter and director fine transmitter. The director fine transmitter is wired to the rotor of the differential; the oil gear transmitter is wired to the stator of the differential (fig. 76). When the rotors of the two transmitters have the same angular position there is a voltage balance between the rotor and the stator of the differential. However, when the voltage between the rotor and the stator is not balanced, a magnetic torque between the rotor and the stator is set up. This magnetic torque causes the rotor of the differential to turn in the direction necessary to reestablish the voltage balance.

(3) The pilot piston (fig. 76) which controls the output of the hydraulic transmission is attached to the rotor of the differential selsyn. The rotor of the differential can move the pilot piston either up or down in varying amounts. The direction and amount of movement of the pilot piston determines the direction and speed of rotation of the hydraulic transmission oil motor.

INDEX

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FM 44–2
C 1

FIELD MANUAL

ANTIAIRCRAFT ARTILLERY

AUTOMATIC WEAPONS

CHANGES No. 1 } DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., *26 November 1952*

FM 44–2, 24 August 1950, is changed as follows:

CHAPTER 18

DIRECT FIRE AT MOVING GROUND AND NAVAL TARGETS

227. GENERAL

Antiaircraft artillery automatic * * * or naval targets. **These may be attacked either by direct or indirect fire methods.**

228. COMPARISON OF AIR TARGETS WITH GROUND TARGETS

* * * * *

d. Antiaircraft sight devices * * * on the device. For terrestrial firing, superelevation **can be taken from a firing table, or it** can be estimated by a rule of thumb. For example, the * * * one target height.

CHAPTER 19

DIRECT FIRE AT STATIONARY TARGETS

* * * * *

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CHAPTER 21 (Added)

INDIRECT FIRE AT SURFACE TARGETS

Section I. GENERAL

253. GENERAL

a. Indirect fire is used against surface targets when the targets cannot be seen or laid upon effectively through the direct fire sights of the weapon. Fire is placed upon the target either by the direct commands of an observer or by commands of an observer operating through a fire direction center.

b. The basic priciples of indirect fire are contained in FM 6-40 Field Artillery Gunnery. Appendix XI of that manual points out changes in field artillery gunnery made necessary by the use of AAA matériel in a field artillery mission. Changes in light AAA matériel and procedures necessary to adapt them to a surface mission are contained in this chapter.

c. The light AAA weapon best suited for indirect fire is the self-propelled twin 40-mm gun T141, which replaces the M19A1. Also, the M16A1 multiple caliber .50 machine gun motor carriage, which replaces the M16, is equipped with azimuth and elevation scales for direct and indirect firing. Although other light AAA weapons may be modified for indirect fire missions (par. 238), the means available for laying for direction are not as accurate. The following paragraphs (254-259) refer only to the self-propelled twin 40-mm gun T141. However, the

same general procedures and techniques apply also to other light AAA weapons.

254. EMPLOYMENT

When using indirect fire techniques in a surface mission, 40-mm guns are normally employed by platoon (four weapons—eight barrels). A platoon fire direction center is located at or near the position area.

255. EMPLACEMENT

a. Due to the flat trajectory of the 40-mm projectile, gun positions must be carefully selected to secure the maximum defilade and still provide the desired target area coverage. To secure proper density of fire on all targets, it is desirable that guns be emplaced about 20 yards apart forming a sheaf 60 yards in width. However, the tactical situation may often require that weapons be dispersed and a greater interval assumed. If this results in a platoon front greatly in excess of 60 yards, corrections are applied at the time the platoon is oriented to reduce the width of the sheaf (par. 259).

b. Regardless of the numerical designation customarily given each weapon within the platoon, guns in a surface-firing position are habitually numbered from right to left, facing the direction of fire.

c. Gun carriages should be cross-leveled, when time permits, to eliminate errors produced by canting of the gun barrels. The level may be checked by using the gunner's quadrant on the two quadrant seats (set at right angles to one another) located on the left pedestal of the T141.

256. CALIBRATION

a. Within the battalion, gun barrels should be calibrated and barrels having similar shooting qualities grouped together within each platoon and on each weapon (FM 6-40, appendix V). This calibration should be conducted initially by ordnance personnel. To supplement this, or if no ordnance calibration is possible, a comparative calibration may be conducted by firing. However, inasmuch as no firing table data are available from which a velocity error (VE) may be computed, the relative shooting qualities of various barrels are determined by a comparison of corrections (K's) in yards per thousand yards of range. Using the average range of all centers of impact as standard, barrels are grouped according to their variation from that standard as expressed by a plus or minus K.

b. Within the platoon, efforts should be made to equalize differences by employing the longest-shooting barrels on the base piece where additional firing will tend to reduce their muzzle velocities. Calibration should be repeated as a check on subsequent barrel wear, and barrels should be regrouped if necessary.

257. ORIENTATION

a. Elevation. Since each round is fired with a gunner's quadrant, no orientation in elevation is required. Quadrant seats are provided on the breech casing of the left gun.

b. Azimuth. Self-propelled twin 40-mm guns are laid for direction by means of azimuth indicators

which indicate azimuth as the weapons are traversed. The T141 has a clock-type azimuth indicator graduated in mils from zero to 6,400. For a more complete description of the azimuth indicator, see TM 9-761A and the service of the piece manual on the T141.

258. METHODS OF ORIENTATION IN AZIMUTH

There are two methods of orienting the guns using the azimuth indicator.

a. Known Datum Point Method. Bore sight the left barrel of the gun on the known datum point by traversing to it. Without moving the gun, set the azimuth to the known datum point on the azimuth indicator using the resetter knob.

b. Backsighting Method. In order to employ this method, an aiming circle must be available. Set up the aiming circle at least 60 yards from the guns, and orient it with reference to grid north, using the compass needle of the aiming circle (FM 6-40). Bore sight the left barrel of the gun on the aiming circle by traversing it until the axis of the bore coincides with the optical center of the aiming circle. With the azimuth knob (upper motion) of the aiming circle, turn the line of sight of the instrument onto the axis of the bore of the gun barrel. When the axis of the bore of the barrel and the line of sight of the aiming circle coincide, the back azimuth of the angle secured from the aiming circle is set on the azimuth indicator as described in *a* above. When each gun in the platoon has been oriented in a similar manner and the same azimuth has been set off on the azimuth indicators, the gun barrels will then be parallel.

259. ADJUSTING THE PLATOON SHEAF

If the width of the platoon sheaf is too great for proper target area coverage (par. 255*a*), it may be adjusted to an effective width by announcing special corrections in azimuth to each of the guns after orientation. The platoon commander determines by the mil relation the number of mils in azimuth each gun must shift to close (open) the sheaf to form a 60-yard sheaf at a range of 4,000 yards. A range of 4,000 yards is chosen arbitrarily as one which will cause a sheaf of optimum effectiveness to be formed at ranges customarily used. This shift is computed by determining the difference between the existing weapon interval and the desired interval (20 yards for a 60-yard sheaf). This difference in yards is converted to mils at 4,000 yards range, using the mil relation. Each weapon, except the base piece, is traversed toward (or away from) the base piece the proper number of mils. Without changing the positions of the barrels, the azimuth indicators of these pieces are then reset to their previous reading.

Example:

a. Computation of Shift.

Platoon front	105 yards
Base piece	Gun No. 2
Interval between guns 1 and 2	35 yards
Desired interval (60÷3)	20 yards
Difference	15 yards
15÷4.0=3.75 or 4 mils	
Interval between guns 2 and 3	30 yards

Desired interval	20 yards
Difference	10 yards

$10 \div 4.0 = 2.5$ or 3 mils

Interval between guns 2 and 4	70 yards
Desired interval	40 yards
Difference	30 yards

$30 \div 4.0 = 7.5$ or 8 mils

b. Application of Shift. Guns have been oriented and laid parallel at azimuth 1,800 mils.

(1) No. 1 gun traverses to the *left* 4 mils (Az 1,796) and resets azimuth indicator at 1,800.

(2) No. 2 gun, the base piece, does not change.

(3) No. 3 gun traverses to the *right* 3 mils (Az 1,803) and resets azimuth indicator at 1,800.

(4) No. 4 gun traverses to the *right* 8 mils (Az 1,808) and resets azimuth indicator at 1,800.

Section II. OBSERVER PROCEDURE

260. GENERAL

Two methods of bringing fire on targets by the commands of an observer may be employed.

a. Target grid procedure.

b. Direct command procedure.

261. TARGET GRID PROCEDURE

This is the observer procedure described in FM 6–40. It is the normal procedure employed with all AAA weapons in indirect surface firing.

262. DIRECT COMMAND PROCEDURE

a. General. This method is intended primarily for use with self-propelled light AAA weapons. It provides a rapid, accurate means of placing fire on targets at ranges beyond the effective vision (2,000 yards) of on-carriage sights or when visibility from the guns is reduced by dust, smoke, defilade, or other causes. It is suitable for use primarily with single weapons where a fire direction center is not available. However, with proper coordination, it may be used to fire a platoon or battery.

b. Limitation. Direct command procedure can best be used when the displacement of the observer from the gun position in any direction is less than one-tenth of the gun-target range (fig. 70.1). This results in a T angle at the target of less than 100 mils; therefore, the observer's sensings along the observer-target line may be converted directly to corrections along the gun-target line. The observer may transmit his commands direct to the gun without resorting to the use of a fire direction center, as in target-grid procedure. However, if the observer is located at a greater distance than this from the guns, target-grid procedure is preferable. If it is apparent that more than one target is to be engaged from any position, the observer should select an observation point so that his lateral location from the gun is less than one-tenth of the gun-target range to the near target.

c. Initial Data. The squad leader of the self-propelled light AAA weapon is normally the observer. Upon entering a surface (indirect) firing position, he

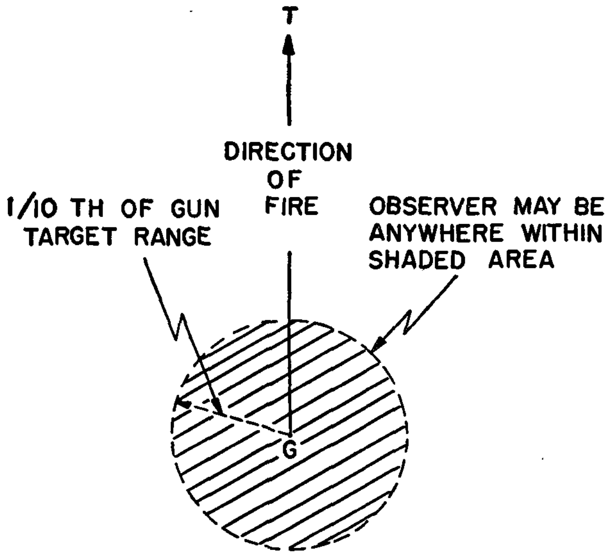


Figure 70.1. Displacement of observer from gun position.

determines certain initial data which are necessary to orient the weapon and to place initial rounds on or near the target.

(1) *Orientation.* The squad leader selects a terrain feature which is visible from the gun as a reference point. He determines the approximate azimuth from the gun to the reference point by means of a map or compass, or he may assume an arbitrary azimuth for this direction line (par. 263). The weapon is oriented in azimuth by alining the barrels on the reference point

and setting the azimuth to that point on the azimuth indicator.

(2) *Initial firing data.* From his observation post near the gun, the observer determines initial data in azimuth and range which will place initial rounds on or near the target.

(*a*) *Azimuth.* The observer determines the azimuth to the target by use of a compass, or by measuring the angle between the reference point ((1) above) and the target with field glasses or any suitable angle-measuring device. The initial azimuth is announced to the gun as AZIMUTH (so much) in mils.

(*b*) *Site.* The difference in altitude between the gun and target is normally estimated or scaled from a map. This difference in altitude, in yards, is converted to a vertical angle in mils by use of the mil rule. If an angle-measuring instrument is available, the angle of site may be measured directly. This is announced to the gun as SITE PLUS (MINUS) (so much) in mils.

(*c*) *Range.* The gun-target range is taken from a map, or is estimated. The range, taken to the nearest 100 yards, is transmitted to the guns as RANGE (so much).

d. Sequence of Fire Commands. Initial fire commands are transmitted in the following sequence:

Sequence	*Example*
(1) Pieces to follow commands.	NO. 1, ADJUST,
(2) Projectile.	SHELL HE,
(3) Pieces to fire.	(Omitted where the pieces to fire are the same as the pieces to follow commands.)
(4) Method of fire.	ONE ROUND, (On twin-gun mounts, this command may be preceded by the designation of a single barrel to fire, e. g., RIGHT (LEFT) BARREL, ONE ROUND. If no mention is made of barrels, each barrel will fire the designated number of rounds).
(5) Direction.	AZIMUTH 1,800,
(6) Site.	SITE PLUS 8,
(7) Range.	RANGE 4,000.

e. Application of Initial Fire Commands at the Gun. The initial fire commands of the observer are applied to the weapon in the following manner:

(1) The first four commands serve to alert the crew and designate the ammunition to be used.

(2) The command for azimuth is transmitted to the azimuth tracker (No. 2), who traverses the weapon to the announced azimuth.

(3) The commands for site and range are transmitted to the quadrant setter (No. 3). From a graphical firing table (GFT), the quadrant setter determines the elevation corresponding to the announced range. He adds the angle of site algebraically to this elevation and sets the resulting sum on the gunner's quadrant. When the quadrant bubble has been leveled, he gives the command FIRE.

f. Subsequent Corrections. The observer adjusts the fire of the gun on the target by sending corrections for subsequent rounds directly to the guns. Shots which are off the observer-target line are brought to that line by commanding a shift in the appropriate direction in mils, e. g., RIGHT (LEFT) 5. The target is bracketed for range, using normal observer procedure, by commanding changes in range in yards, e. g., ADD (DROP) 400. The initial range bound should be large enough to insure bracketing the target in range. This bracket is successively split until the target is within a bracket of suitable size, depending on the nature of the target. Fire for effect is begun at the center of that bracket. It should be noted that at ranges up to 4,000 yards the fragmentation effect of the 40-mm projectile is mainly forward of the point of impact with some side spray and a negligible amount of base spray. Therefore, when firing at less than 4,000 yards, fire for effect is normally placed short of the center of the target. Corrections are announced in the following sequence:

Sequence	*Example*
(1) Change in ammunition.	SHELL AP.
(2) Change in method of fire; for example, to change the number of rounds upon entering fire for effect or to change from single barrel to twin barrels to facilitate sensing.	10 ROUNDS, (or BOTH BARRELS).
(3) Deviation correction.	RIGHT 10.
(4) Range correction.	DROP 50.

Note. Subsequent corrections are always terminated with a correction for range. Any element which is not being changed may be omitted, except range; if no change is desired in range, the observer sends REPEAT RANGE.

g. Application of Subsequent Corrections at the Gun.

(1) When a change in azimuth is announced by the observer, the azimuth tracker traverses the gun until this new azimuth is set on the azimuth indicator. The azimuth tracker must bear in mind that azimuths decrease when moving to the left and increase when moving to the right. For example, a shift of RIGHT 60 from an azimuth setting of 1,367 would result in a new setting of 1,427 (1,367+60). A subsequent command of LEFT 35 would change the setting to 1,392 (1,427−35).

Note. The gunner's aid dial (outer dial) of the azimuth indicator is used as an aid in the computation of new azimuths. For complete instructions on the use of the azimuth indicator and the gun-

ner's aid dial, see the service of the piece manual for the T141 (when published).

(2) In handling subsequent corrections in range, the quadrant setter uses the c (change in elevation for a 100-yard change in range) corresponding to the initial range command. The value of c in mils is taken from a graphical firing table. The quadrant setter multiplies the c by the range correction in hundreds of yards. He applies the resulting value in mils arithmetically to the last quadrant fired. For example, assume a round was fired at a quadrant of 70 and that the c is 3 mils. If a range change of ADD 400 were ordered, the quadrant setter would set his quadrant at 82 (70+3 x 4). A subsequent correction of DROP 200 would result in a quadrant setting of 76 (82−3 x 2).

263. DIRECT COMMAND PROCEDURE USING TANK AZIMUTHS

The use of assumed tank azimuths provides a rapid and effective means of preparing initial data and orienting self-propelled weapons for firing, using direct command procedure. This method is especially applicable to situations where neither the time nor the means are available to determine grid azimuths. To employ tank azimuths, the azimuth indicator of the weapon is set at zero, with the guns locked in the forward traveling position. Tank azimuths are clockwise angles measured from the center line of the vehicle with the front of the vehicle

assumed to be zero azimuth (fig. 70.2). The observer uses the direction in which the vehicle is pointing as a basis for computing tank azimuths to targets. If time is available before the weapon occupies position, the observer selects a reference point toward which the driver will point his vehicle upon moving into position. This reference point is assumed to have an azimuth of zero mils, and an approximate orientation on this assumed azimuth is accomplished when the vehicle is lined up on this point. The observer determines the tank azimuth to the target by measuring directly from the reference point. Before the weapon has occupied position, the driver has the reference point identified to him and the crew is given sufficient data to enable the initial rounds to be fired immediately upon occupying position. These data should include—

a. Shell.

b. Method of fire.

c. Tank azimuth to target.

d. Angle of site.

e. Initial range.

264. ILLUSTRATIVE EXAMPLE, DIRECT COMMAND PROCEDURE

Area fire mission; target, machine gun position; mission, neutralization; matériel, one 40-mm weapon (T141). The weapon has been oriented on a reference point with an approximate azimuth. Observer is 120 yards to right of the gun position. He estimates azimuth to target as 1,800 mils. Range to target is estimated at 4,000 yards, difference in altitude is +30 yards. Angle of site is therefore +8 (30÷4.).

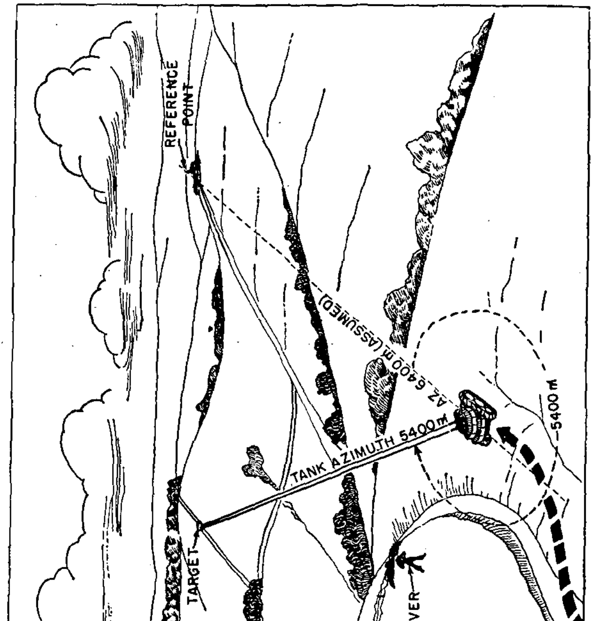
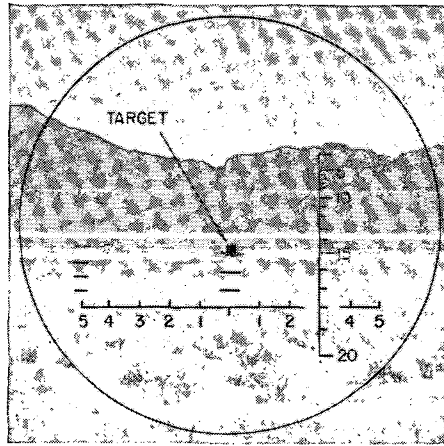
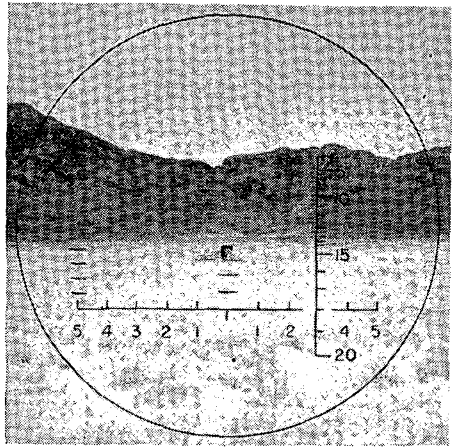


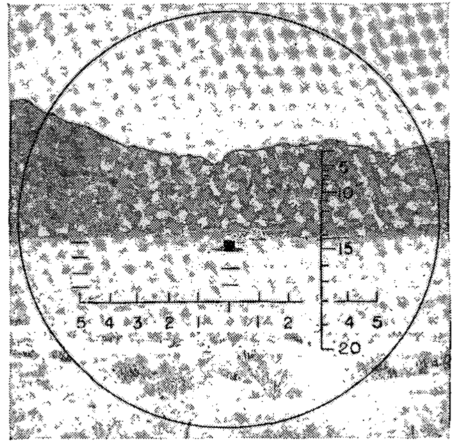
Figure 70.2. Tank azimuths used with direct command procedure.

Commands	Results	Sensings	
		Rn	Dev
Observer to gun: NO. 1 ADJUST, SHELL HE, ONE ROUND, AZIMUTH 1,800, SITE PLUS 8, RANGE 4,000. *Action of gun crew:* Azimuth tracker—traverses until 1,800 appears on azimuth indicator. Quadrant setter—determines elevation for 4,000 yards range from GFT (62). Notes value of c is 3 mils. Adds angle of site of 8 mils and sets result (70) on quadrant. When quadrant bubble is level, commands FIRE.	 *Figure 70.3 First volley.*	?	45L

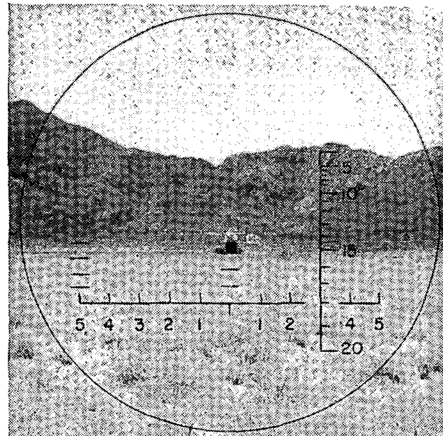
Remarks: Inasmuch as no mention was made of barrels to fire, both barrels of the weapon fire.

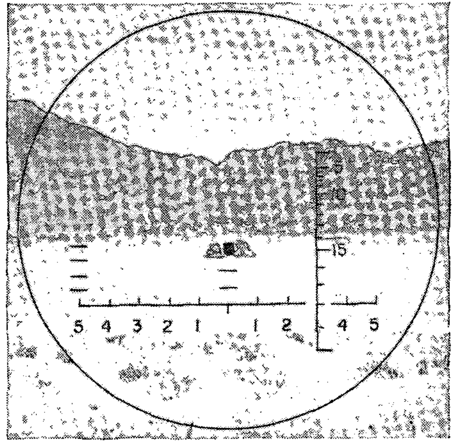
Commands	Results	Sensings	
		Rn	Dev
Observer to gun: RIGHT 45, REPEAT RANGE. *Action of gun crew:* Azimuth tracker—adds 45 to 1,800, sets 1,845 on azimuth indicator. Quadrant setter—fires piece at Q70.	 *Figure 70.4 Second volley.*	—	Line

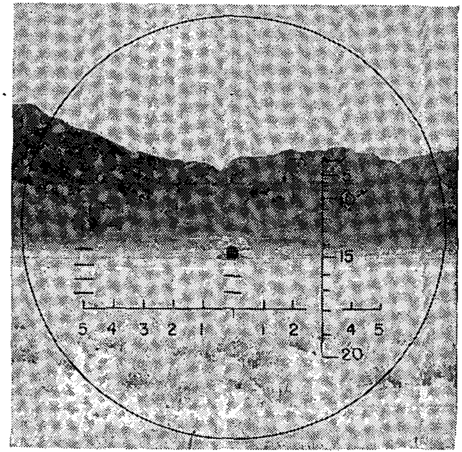
Remarks: Initial data estimated. Observer decides a range change of 400 yards will establish a bracket.

Observer to gun: ADD 400. *Action of gun crew.* Quadrant setter—multiplies range change in hundreds of yards (4) x the c of 3. Adds result (12) to last quadrant setting (70) and sets quadrant at 82. Fires piece at Q82.	 *Figure 70.5 Third volley.*	+	5R

Remarks: Small deviation is caused by the target offset (30 mils). Observer elects to ignore it unless it persists inasmuch as he is able to obtain range sensings.

Commands	Results	Sensings	
		Rn	Dev
Observer to gun: DROP 200. *Action of gun crew:* Quadrant setter—computes new quadrant setting: $-2. \times 3 = -6. \quad 82-6=76.$ Fires piece at Q76.	 *Figure 70.6 Fourth volley.*	+	2R

Observer to gun: DROP 100. *Action of gun crew:* Quadrant setter—1. x 3=3. 76−3=73. Piece is fired at Q73.	 *Figure 70.7 Fifth volley.*	—	Line

Commands	Results	Sensings	
		Rn	Dev
Observer to gun: ADD 50. *Action of gun crew:* Quadrant setter—.5 x 3=1.5. 73+1.5=74.5 Piece is fired at Q75.	 *Figure 70.8 Sixth volley.*	+	Line

Remarks: Normally, observer would enter fire for effect upon splitting a 100-yard bracket. However, since target is a single machine gun position, observer elected to withhold fire for effect until sensing

obtained on this round. Inasmuch as the effect of the round is clearly over the target, observer decides to refine the bracket further by a small change in the proper direction. Since target is a single machine gun position, the observer decides to split a 50-yard bracket before entering fire for effect.

Observer to gun:
5 ROUNDS.
DROP 30.

Action of gun crew:
No. 4—prepares 5 rounds of ammunition for each barrel. Quadrant setter—.30 x 3 = .90. 75 − .90 = 74.10 (Use 74). Fires piece at Q74.

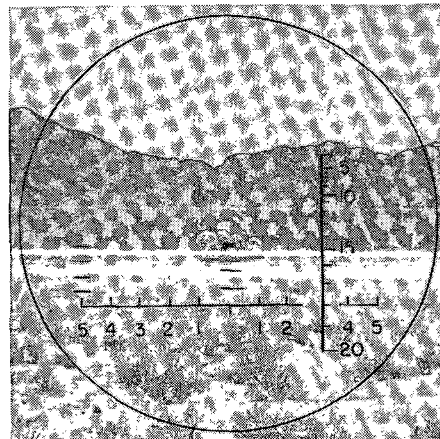


Figure 70.9 Seventh volley.

Correct

Remarks: Fire effectively covers area and machine gun appears to be silenced. Observer sends to gun, CEASE FIRING, END OF MISSION, MACHINE GUN NEUTRALIZED.

APPENDIX VI

TACTICAL FIRING EXERCISES FOR LIGHT ANTIAIRCRAFT ARTILLERY IN CLOSE FIRE SUPPORT OF INFANTRY OR ARMOR

(Added)

Section I. GENERAL

1. PURPOSE

This appendix is intended as a guide for the preparation and conduct of tactical firing exercises for light antiaircraft artillery when employed in close fire support of infantry or armor. The exercises are designed for light AAA platoons; however, they are easily adapted to larger units.

2. SCOPE

The exercises presented embrace the combined firing and tactical phases of close fire support. Provision is made for scoring both phases.

3. REFERENCES

The principles of employment of light AAA in a close fire support mission are contained in chapter 3. For antiaircraft artillery service practice procedures and standards, see TM 44–234. In a close fire support mission, light AAA is often reinforcing the fires of infantry heavy weapons and must work in close coordination with infantry and armor units. For information as to the tactics of infantry and armor

units, see appropriate field manuals of the 7 and 17 series.

4. PREPARATION OF TACTICAL EXERCISES

a. General. Tactical exercises must be carefully prepared by the instructor (chief umpire) based upon the requirements of each exercise as set out below. These exercises do not attempt to cover all the situations which might be encountered. They are designed instead, to provide training in the basic principles of employment in typical combat situations. They may be modified to meet local conditions and the particular needs of a light AAA unit.

b. Tactical Situation. The tactical situations should be realistic and clear. The initial situation describes the situation as it exists at the beginning of the exercises and gives only as much information of the enemy as will affect the action of the unit. The initial requirement assigns the unit a definite mission covering a particular combat phase. Available terrain permitting, related exercises are based on a continuing situation.

c. Terrain. The instructor should make a thorough reconnaissance of the available terrain in order to select the most suitable area for the conduct of the exercise. Whenever possible, the area chosen should be one which will permit firing from realistic positions during the exercise.

d. Representation of Friendly and Enemy Troops. Elements of supported infantry units may be represented by umpire personnel. In nonfiring exercises, the use of Aggressor forces is encouraged to lend realism to the problem.

e. Ammunition. Weapons fire in each exercise whenever permitted by range facilities and ammunition allowances (par. 5, this app.).

f. Targets. Combat realism should be stressed in the selection of targets to be fired upon. Ideal targets are clumps of bushes and trees or other terrain features which would be logical places of concealment for troops and weapons. Camouflaged gun emplacements, simulated pillboxes, and other dummy installations may be used. The instructional value of the exercise may be enhanced by placing silhouette targets or effect boards in concealed positions within areas used as targets. Although scoring is not based on the effect had on these simulated personnel, the participating unit is given a graphic demonstration of the effectiveness of its fire.

5. CONDUCT OF FIELD EXERCISE

a. General. Battle conditions are simulated as closely as possible. The exercise tests the application of technical and administrative training as well as tactical training. For a detailed discussion, see FM 21–5. A general critique is held at the conclusion of the exercise. In addition, the units are scored on their conduct of the exercises as indicated below.

b. Umpires. For the responsibilities, duties, and conduct of umpires, see FM 105–5. The instructor directs the exercise, serves as chief umpire, and is responsible for safety during firing. He does not command the unit participating in the exercise.

Assistant umpires (who may be NCO's) are used to check the execution of the tactical phases and the effectiveness of the firing. They also check to insure the observance of safety regulations. Normally, an umpire is assigned to each fire unit in the platoon and scores that unit on its performance in the exercise.

c. Ammunition and Firing. Within the limitations imposed by safety requirements, range facilities, and ammunition allowances, fire units of the platoon fire on simulated targets. The number of targets fired upon in each exercise will depend upon the ammunition available. The amount of ammunition to be expended on each target should be specified in advance. Normally, it will not exceed 10 rounds per barrel for 37-mm and 40-mm guns and 50 rounds per barrel for .50-caliber machine guns. Initial targets (prearranged targets or fires) on which fire is requested by the infantry are pointed out by the infantry battalion commander. The platoon commander includes these targets in his original fire support plan. Additional targets (targets of opportunity), not included in this plan, are selected by umpires and fire is requested on these targets during the exercise through normal fire request channels. Such targets are usually engaged on—

(1) Request from the infantry battalion commander (or the heavy weapons company commander) to the platoon commander.

(2) Request by radio from AAA forward observers (where employed) with attacking rifle companies.

(3) Initiative of the platoon commander or fire unit commanders when authorized to engage targets of opportunity.

d. Lifting Fires. Fire on any target should be lifted when—

(1) An umpire indicates the target is either neutralized or destroyed or that the infantry has reached a predesignated safety line or area.

(2) Ordered by the infantry battalion commander.

(3) The fire of any unit might violate safety requirements.

e. Development of the Action. The plan for conducting the exercise includes the progressive development of the action by the representation of friendly and enemy action and fires. The arrival of messages and orders and the appearance of friendly and hostile aircraft and tanks are also represented. Portions of the exercises calling for close coordination of the actions of the AAA platoon with supported troops must be carefully planned by the instructor. Where infantry units are represented by umpires, plans for the exercise should call for actual preparation of fire plans for infantry heavy weapons and preparation of counterattack plans, withdrawal plans, etc. During the conduct of the exercise, a reasonable time is given leaders for reconnaissance, decisions, plans, and issuance and execution of orders.

f. Critique. A critique is conducted on the ground immediately after each tactical exercise. The performance of the unit as a whole and of each fire unit

is discussed by the instructor on the basis of all notes and score sheets.

g. Scoring. The platoon's performance in the exercise is given a numerical rating based on weights and standard procedures set out for each exercise. Umpires at each fire unit, using field glasses, observe the effect of that unit's fire on targets. The effectiveness of fire is scored on the score sheet illustrated in figure 77. Bursts of fire delivered at various intervals on the same area may be scored as if fired at a single target and graded on the over-all effectiveness of the total rounds fired. Normally, the speed, quietness, and orderliness with which each operation is executed will be given weight. The size of cuts for speed, quiet, and orderliness are at the discretion of the umpire, but should not exceed a total of 20 percent of the score for each operation in an exercise.

Section II. OFFENSIVE COMBAT EXERCISE

6. GENERAL

This problem illustrates the principle of close fire support employed by a light AAA platoon attached to an infantry battalion in an attack. Necessary elements of the supported unit may be represented by umpires.

7. REQUIREMENTS

Prior to the attack, the platoon is in an assembly area to the rear of the infantry battalion positions. The platoon commander reports to the infantry battalion commander and receives information

TARGET SCORE SHEET

UNIT.................................. WEAPON..............................

DATE.................................. UMPIRE..............................

PLACE................................. AVERAGE SCORE.......................

1. ENGAGEMENT TIME.[1]

TARGET No.	1	2	3	4	5	6	7	8	9	10
WEIGHT 5										

a. Prearranged fires. Cut score if fire is not placed on targets promptly and according to the fire plan. Size of cut is at umpire's discretion.
b. Targets of opportunity. Cut one point for each second over 3 seconds from time of identification of target (by gun layers) to time of opening fire.

2. ADJUSTMENT TIME.[1]

TARGET No.	1	2	3	4	5	6	7	8	9	10
WEIGHT 6										

Time from first impact in target area to first target hit.

a. Target hit on first round (burst).	(6)
b. 0–5.9 seconds.	(5)
c. 6–7.9 seconds.	(4)
d. 8–8,9 seconds.	(3)
e. 9–9.9 seconds.	(2)
f. 10 seconds or over.	(0)

3. EFFECT ON TARGET.

TARGET No.	1	2	3	4	5	6	7	8	9	10
WEIGHT 10										

a. Almost all rounds appeared to hit.	(10)
b. More than half appeared to hit.	(8)
c. Over one-quarter of rounds appeared to hit.	(6)
d. Very few rounds appeared to hit.	(3)
e. No rounds appeared to hit.	(0)

4. PERFORMANCE OF CREW.

TARGET No.	1	2	3	4	5	6	7	8	9	10
WEIGHT 4										
TOTALS. 25										

[1] Where indirect fire is employed (either to take advantage of defiladed positions or because of extreme target ranges), cuts are made in engagement time and adjustment time scores only for wasted time or unreasonable delays in briuging fire on the target.

Figure 77. Target score sheet, light AAA close fire support exercise.

regarding the situation. Following a reconnaissance, the platoon commander presents his fire plan to the infantry battalion commander and moves his platoon into firing positions in time to support the attack. As the attack progresses, the platoon is displaced forward at least once, if possible, in order to continue rendering effective support. At a certain point in the attack (usually where the infantry is assumed to have just taken an objective), the instructor may represent to the platoon commander that a counterattack has begun. New targets are designated and the platoon shifts its fires to cover this threat. The exercise is terminated at the discretion of the instructor.

8. SCORING

The performance of the platoon in both tactical and firing phases will be scored. Weights are as follows:

	Nonfiring exercise (percent)	*Firing exercise (percent)*
a. Reconnaissance	15	10
b. Platoon commander's plan	25	20
c. Selection and occupation of position	20	15
d. Liaison and communication	15	10
e. Displacement	15	10
f. Ammunition supply	10	10
g. Fire control and effectiveness of fire. For details, see score sheet, figure 77	----	25
	100	100

9. STANDARD PROCEDURES

The following standard procedures may be used as a guide in scoring the platoon.

a. Reconnaissance. For information on the conduct of the reconnaissance by the platoon commander and on the nature of the information to be sought, see paragraphs 83*b* and 84*a*.

b. Platoon Commander's Plan. After coordinating the results of his reconnaissance with the infantry heavy weapons commander, the platoon commander formulates a plan for the employment of his platoon in the attack. It is presented to the infantry battalion commander as a recommendation. For further details, see paragraphs 55 and 84*b*.

c. Selection and Occupation of Positions. Weapons should be emplaced as far forward as possible without undue exposure in occupation of positions and without exposure to enemy small arms fire. Rear slopes, flanks of terrain features, and depressions in the ground are utilized, or the weapons are dug in and sandbagged. For direct fire, caliber .50 machine guns are emplaced within 1,000 yards, and 37-mm and 40-mm guns are emplaced within 1,500 yards of the target area if practicable, considering the other requirements of a position. Where the terrain and situation permit, consideration should be given to employing 40-mm weapons in indirect fire positions utilizing as much defilade as possible. On targets beyond effective vision of on-carriage sights (1,500–2,000 yards), indirect fire techniques should be used.

The following are the requirements of a firing position in order of their importance:

(1) Ability to place effective fire on the immediate objective.

(2) Field of fire.

(3) Cover.

(4) Concealment.

(5) Alternate positions available.

(6) Route into and out of position.

d. Liaison and Communication. For details as to the liaison and communication to be established, see paragraphs 54 and 87.

e. Forward Displacement. Elements of the platoon should be displaced forward whenever necessary to provide effective support. Displacement is normally by echelon. For further details, see paragraph 84*b*(2).

f. Ammunition Supply. The ammunition supply plan is part of the platoon commander's plan of maneuver. It may be realistically carried out in this exercise by the use of actual ammunition or by representing both the weight and volume of the ammunition. For further details, see paragraph 84*b*(3).

g. Fire Control. Unless communication failure or emplacement over a wide front dictates decentralization of fire control, best results are obtained by centalized fire control under the platoon commander. Fire should be quickly adjusted on prearranged targets, using either direct or indirect fire, according to the fire plan of the platoon commander. The time of opening fire and target priorities are pre-

scribed by the infantry battalion commander. For further details, see paragraph 85.

Section III. DEFENSIVE COMBAT EXERCISE

10. GENERAL

This problem illustrates the principles of close fire support employed by a light AAA platoon attached to an infantry battalion in defensive combat.

11. REQUIREMENTS

The platoon has been attached to an infantry battalion and is in an assembly area to the rear of the defensive positions to be occupied. The units are out of contact with the enemy, and ample time is available for reconnaissance. If possible, the platoon commander accompanies the infantry commander on reconnaissance; he then makes his own reconnaissance for the AAA platoon positions. After approval of the platoon commander's fire plan by the infantry commander, the platoon moves into positions selected. The attack by the enemy is simulated under the control of the instructor. The platoon places its fire plan into execution and fires both at prearranged targets and at targets of opportunity. At a certain point in the enemy attack, the instructor may represent that friendly infantry units are counterattacking. Elements of the AAA platoon are required to move into previously selected and prepared positions to support this attack. If

time permits, the instructor may represent that the infantry is to withdraw immediately from present positions to new positions to the rear. Plans for the withdrawal call for a portion of the platoon to remain as part of the covering force. The platoon commander makes reconnaissance for weapon locations in the new positions. He plans the withdrawal of the platoon in echelons with elements of the infantry, and coordinates the fire plan of the AAA weapons in the covering force with the infantry weapons fire plan. During the withdrawal, fire units with the covering force fire according to plan and also engage targets of opportunity. The exercise may be terminated when all elements of the platoon reach the new defensive positions.

12. SCORING

The performance of the platoon in both tactical and firing phases will be scored. Weights are as follows:

	Nonfiring exercise (percent)	*Firing exercise (percent)*
a. Reconnaissance	15	10
b. Platoon commander's fire plan	25	20
c. Selection and occupation of position	20	15
d. Liaison and communication	15	10
e. Employment in counterattack	15	10
f. Ammunition supply	10	10
g. Fire control and effectiveness of fire. For details, see score sheet, figure 77	----	25
	100	100

13. STANDARD PROCEDURES

The following standard procedures may be used as a guide in scoring the platoon.

a. Reconnaissance. For information on the conduct of the reconnaissance by the platoon commander and on the nature of the information to be sought, see paragraph 59.

b. Platoon Commander's Plans and Recommendations. Based on his ground reconnaissance, the platoon commander submits recommendations to the infantry commander concerning the employment of the platoon (par. 60). A fire plan for the employment of the AAA weapons is evolved in coordination with the infantry, based upon these recommendations. For further details as to this plan, see paragraphs 60 and 65.

c. Selection of Positions. For direct fire, caliber .50 machine guns are emplaced within 1,000 yards of possible targets and 37-mm and 40-mm guns within 1,500 yards, if practicable, considering the other requirements of a position. Where terrain and situation permit, consideration should be given to employing 40-mm weapons in indirect fire positions utilizing as much defilade as possible. On targets beyond effective vision of on-carriage sights (1,500-2,000 yards), indirect fire techniques should be used. Positions should be selected with following factors in mind:

(1) Protection of vital terrain features.

(2) Retention of essential observation to front and flanks.

(3) Denial to the enemy of close observation into the battle position.

(4) Provision of good fields of fire for weapons located in the rear portions of the battalion area.

(5) Utilization of natural cover and concealment.

(6) Security from enemy small arms fire.

(7) Coordination with the infantry on the battle position for mutual protection.

d. Liaison and Communications. Liaison and communications are established as in the attack (par. 9*d* this app.).

e. Employment in Support of Counterattack. The fire plan should include provision for the employment of AAA weapons in support of a counterattack. For details, see paragraph 65*b*.

f. Fire Control. Fire control is maintained as in the attack (par. 9*g* this app.).

g. Ammunition Supply. Provisions for the supply of ammunition are the same as those made during the attack (par. 9*f* this app.).

[AG 300.7 (24 Oct 52)]

BY ORDER OF THE SECRETARY OF THE ARMY:

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